ACTA BOTANICA

ACADEMIAE SCIENTIARUM HUNGARICAE

ADIUVANTIBUS

G. L. FARKAS, G. FEKETE, V. FRENYÓ, T. HORTOBÁGYI,
P. JUHÁSZ-NAGY, I. MÁTHÉ, S. SÁRKÁNY, T. SIMON,
R. SOÓ, B. ZÓLYOMI

REDIGIT

P. JAKUCS

TOMUS XXII FASCICULI 1—2

AKADÉMIAI KIADÓ, BUDAPEST
1976

ACTA BOT. HUNG.

ACTA BOTANICA

A MAGYAR TUDOMÁNYOS AKADÉMIA BOTANIKAI KÖZLEMÉNYEI

SZERKESZTŐSÉG ÉS KIADÓHIVATAL: 1054 BUDAPEST, ALKOTMÁNY UTCA 21.

Az *Acta Botanica* német, angol francia és orosz nyelven közöl értekezéseket a botanika tárgyköréből.

Az *Acta Botanica* változó terjedelmű füzetekben jelenik meg, több füzet alkot évenként egy kötetet.

A közlésre szánt kéziratok a következő címre küldendők:

Acta Botanica, Budapest 502, Postafiók 24.

Ugyanerre a címre küldendő minden szerkesztőségi és kiadóhivatali levelezés.

Megrendelhető a belföld számára az „Akadémiai Kiadó"-nál (1363 Budapest Pf 24. Bankszámla 215.11428), a külföld számára pedig a „Kultúra" Könyv- és Hírlap Külkereskedelmi Vállalatnál (1389 Budapest 62, P.O.B. 149. Bankszámla 218-10990) vagy annak külföldi képviseleteinél, bizományosainál.

Die *Acta Botanica* veröffentlichen Abhandlungen aus dem Bereiche der botanischen Wissenschaften in deutscher, englischer, französischer und russischer Sprache.

Die *Acta Botanica* erscheinen in Heften wechselnden Umfanges. Mehrere Hefte bilden einen Band.

Die zur Veröffentlichung bestimmten Manuskripte sind an folgende Adresse zu senden:

Acta Botanica, Budapest 502, Postafiók 24.

An die gleiche Anschrift ist auch jede für die Redaktion und den Verlag bestimmte Korrespondenz zu richten. Abonnementspreis pro Band: $ 32.00.

Bestellbar bei dem Buch- und Zeitungs-Aussenhandels-Unternehmen »*Kultúra*« (1389 Budapest 62, P.O.B. 149 Bankkonto Nr. 218-10990) oder bei seinen Auslandsvertretungen und Kommissionären.

ACTA BOTANICA

ACADEMIAE SCIENTIARUM HUNGARICAE

ADIUVANTIBUS

A. BORHIDI, G. L. FARKAS, G. FEKETE, V. FRENYÓ,
T. HORTOBÁGYI, P. JUHÁSZ-NAGY, I. MÁTHÉ, S. SÁRKÁNY,
T. SIMON, R. SOÓ, B. ZÓLYOMI

REDIGIT

P. JAKUCS

TOMUS XXII

AKADÉMIAI KIADÓ, BUDAPEST

1976

INDEX

Bizot, M.—Dury, M. N.—Pócs, T.: East African Bryophytes, II 1
Borbély, F.—Borbély, I.—Elek, E.—Kecskés, M.: Mass of weeds and the frequency of weed species affected by herbicides in a lupin culture-consociation 269
Borhidi, A.—Muñiz, O.: Plantes nuevas en Cuba V 295
Dévay, M.—Páldi, E.—Kovács, I.: Thermolabile and thermostable interphases in the vernalization of winter wheat (Triticum aestivum var. Bánkuti 1201) 9
Dézsi, L.—Simon, T.: Investigation of the K-, Ca-, P-, N- and aminoacid content of the epiphytic Hypnum cupressiforme 17
Draskovits, R. M.—Fekete, G.: Chlorophyll concentration and its ecological significance in some species in beechwoods 29
Endrédi, L.—Horváth, I.: Organic matter production and photosynthetic energy utilization of a plant association in loess grassland 39
Fekete, G.—Précsényi, I.—Molnár, E.—Melkó, E.: Niche studies on some plant species of a grassland community I. Comparison of various measurements 321
Gönczöl, J.: Ecological observations on the aquatic Hyphomycetes of Hungary, II 51
Gönczöl, J.: Clavatospora flagellata sp. nov. an aquatic Hyphomycete from Hungary ... 355
Hortobágyi, T.: On the thick-spined species of Micractinium 361
Horváth, M. M.—Nemcsók, J.: Changes in the peroxidase enzyme and in its ability to hydroxylate under the effect of actinomycin D and chloramphenicol in seedling bean plants 367
Juhász-Nagy, P.: Spatial dependence of plant populations. Part I Equivalence analysis (An outline for a new model) 61
Kárász, I.: Shrub layer phytomass investigations in the Quercus petraea-Qu. cerris ecosystem of the Sikfőkút research area 79
Komáromy, P. Zs.: Soil algal growth types as edaphic adaptation in Hungarian forest and grass steppe ecosystems 373
Kovács M.: Die Bedeutung der Balaton-Uferzone für den Umweltschutz am See 85
Kováts, D.: Data on the taxonomy and morphology of Phleum bertolonii DC. and Phleum pratense L. 107
Lakatos, Gy.: On the photosynthesis and chlorophyll efficiency in benthonic communities dominated by Vaucheria dichotoma Agh. in lake Velence (Hungary) 381
Medve, F.: Air pollution of the ecosystem area of an oakwood and the natural 3.4 benzopyrene content of the soil and plant samples in the ecosystem 393
Melkó, E.: Numerical taxonomic studies on Iris pumila L. by cluster analysis 403
Mészáros, Z.: The Melocactus species of Cuba 127
Nosek, J. N.: Comparative analysis of some diversity functions under different conditions of sampling in sandy meadow 415
Orbán, S.—Pócs, T.: Rhodobryum ontariense (Kindb.) Kindb. in Central Europe 437
Péterfi, I.—Nagy-Tóth, F.—Barna, A.: Some results of the researches of Cluj concerning the nutrition of algae 149

Pócs, T.: Bioclimatic studies in the Uluguru mountains (Tanzania, East Africa), II 163
Précsényi, I.—Czimber, Gy.—Csala, G.—Szőcs, Z.—Molnár, E.—Melkó, E.: Studies on the growth analysis of maize hybrids (OSSK-218 and DKXL-342) 185
Priszter, Sz.: Über einige Pflanzen des Westlichen Tienschan, II 201
Rowley, J. R.—Járai-Komlódi, M.: Observation of one pollen grain by SEM, TEM, and light microscopy 449
Szujkó-Lacza, J.: The current space demand and its variability during development of Pimpinella anisum L. 463
Terpó, A.: The carpological examination of wild-growing vine species of Hungary, I ... 209
Wasser, S. P.—Garibova, L. V.—Mokeeva, V. L.: Morphometry of spores and substantiation of a new system in the genus Agaricus Fr. emend. Karst. 249

Recensiones 259, 475

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1—2), pp. 1—8 (1976)

EAST AFRICAN BRYOPHYTES, II

COLLECTIONS MADE BY L. RYVARDEN IN MALAWI, SE AFRICA

By

M. BIZOT, M. N. DURY and T. PÓCS

UNIVERSITY OF DIJON, FRANCE — TEACHERS' COLLEGE, EGER, HUNGARY

(Received January 27, 1976)

Sixty species of bryophytes were collected by Dr. LEIF RYVARDEN (University of Oslo, Norway) in March 1973, mostly from the Mulanje Mountains. A great part of the records is new for the country and two species, *Campylopus flaccidus* (with a new form) and *Leucoloma albocinctum*, are new for the African continent, previously known only from Madagascar and from the Mascarenes. The largest group of 10 species is distributed in SE Africa, 4 were known from South Africa only, 9 are East African, 3 afromontane, 2 afroalpine and the others have a wider distribution.

Introduction

Dr. LEIF RYVARDEN, a mycologist from Oslo University, Norway, accompanied by ENAR SAHLIN, a phanerogam botanist from Göteborg University, Sweden, visited the southern part of Malawi in March 1973. As Malawi is a bryologically neglected country, Dr. RYVARDEN kindly offered to collect some bryophytes which were sent us for identification, for which we express our gratitude. We are also indebted to Drs. R. GROLLE (Jena), J. VÁŇA (Praha), and to Professors J. L. DE SLOOVER (Namur) and C. VANDEN BERGHEN (Louvain) for their kind help in identifying or revising some problematic taxa. If not otherwise stated, the Hepatics were identified by T. PÓCS and the Musci by M. BIZOT and Mlle M. N. DURY.

Ten of the 60 species have already been published in BIZOT and PÓCS (1974), viz.: *Gottschelia schizopleura*, *Schistochila limbata*, *Ptychanthus striatus*, *Metzgeria hamata*, *Campylopus procerus*, *Rhizogonium spiniforme*, *Rhacocarpus purpurascens*, *Trachypodopsis laxoalaris*, *T. serrulata* var. *serrulata* and *Rigodium kilimandscharicum*.

In the enumeration the locality number and the collecting number of Dr. RYVARDEN are given after the species name. The name of the geographical element, to which the species belong, is stated in brackets. Thereafter we have given the known distribution, using the abbreviations published in our *East African Bryophytes I*, pages 397 and 399.

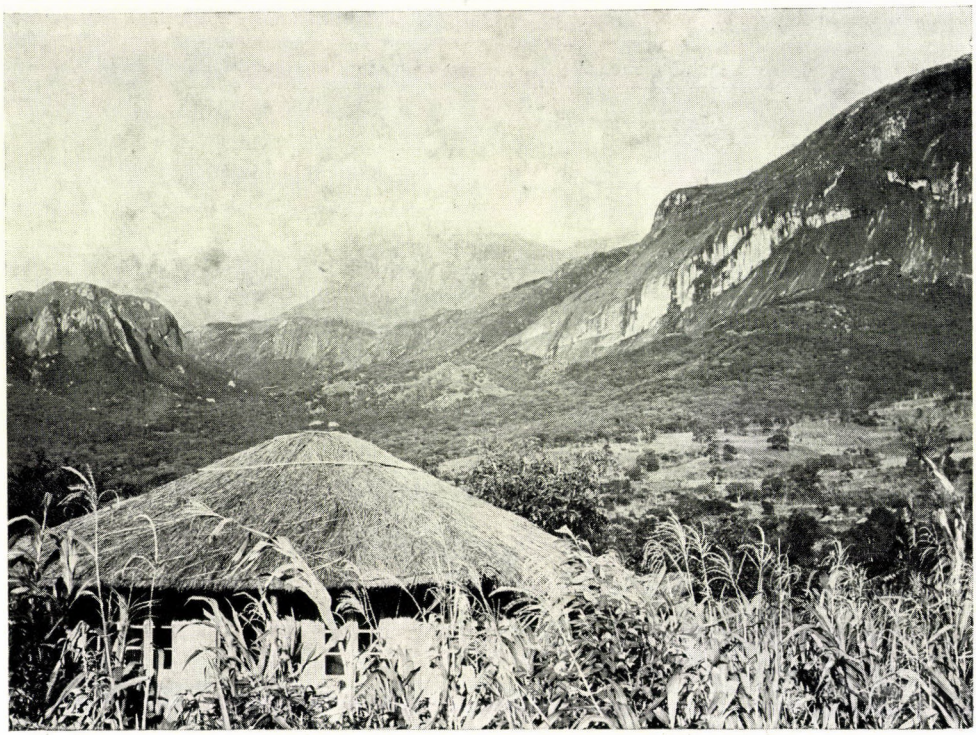


Fig. 1. Likabula Valley seen from the West. Phot. E. SAHLIN

The collecting localities

1. Mulanje Mountains, Likabula Valley, at 900—1600 m altitude, submontane and montane evergreen forests. Most of the specimens reported in this paper were collected below the steep cliff on the left in Fig. 1. The locality lies at 15°55' S and at 35°30' E. Date: 9—10 March 1973.

2. Mulanje Mountains, Lichenya Plateau, at 1800—2000 m altitude. The plateau, often covered by mist, is rich in moorland and peat bog vegetation, with scattered forests along the streams. The emergent, rocky parts are dominated by a shrub-like monocotyledon, *Vellozia splendens* (see Fig. 2). The locality lies at 15°58' S and at 35°30' E. Date of collection: 9—10 March 1973.

CHAPMAN and WHITE (1970: 162—163) describe Mt. Mulanje as follows: "Mt. Mlanje is situated in the south-east corner of Malawi, close to the Mozambique border . . ." "Mt. Mlanje is the most prominent mountain feature in south-central Africa. An isolated massif of about 500 square kilometres (200 square miles), it rises abruptly to nearly 2450 m . . . above the surrounding plains, which lie at a general level of 600 m . . . Mt. Mlanje consists essentially of a large syenitic intrusion . . ."

" . . . Lichenya Plateau, which faces south-east, has a main annual rainfall of 3108 mm, with 643 mm falling in the dry season. At the foot of the mountain below Lichenya . . . the mean annual rainfall is 2425 mm with no month receiving less than 50 mm."

3. Thyolo District, Thyolo (Cholo) Mt., at 1100—1400 m altitude, 16°5' S—35°4' E. Date: 13 March 1973. "The forest of the main block is *Chrysophyllum gorungosanum* submontane forest" (l. c. page 156). "The Shire Highlands lie to the south of Zomba Mt. . . . Their western ridge overlooks the Rift Valley. The highest part of the escarpment is formed by Cholo Mt. (l. c. page 154). The main annual rainfall varies between 1200—1300 mm and the mist effect is also significant according to the available data.

Fig. 2. Rocky vegetation dominated by *Vellozia splendens*, in the higher parts of Lichenya Plateau. Phot. E. SAHLIN

List of species

HEPATICAE

Telaranea nematodes (Gottsche ex Aust.) Howe Syn.: *T. sejuncta* (Angstr.) S. Arnell — 2: 11770 (Oceanic cosmopolite, in Africa: Cape, Nat, Tvl, SE-Zre, Kil).

Kurzia tabularis (St.) Grolle — 1: 11734/B (South African: Cape).

Bazzania adnexa (Mont.) Trev. Syn.: *B. decrescens* (Lehm. et Lindenb.) Trev. — 2: 11790 (Palaeotropic: in Africa Nat, Tvl, Por, Wus, Ulu, Kil, Ruw, Comores, Mad, Réu).

Calypogeia arguta Nees et Mont. ex Nees — 2: 11770/B (Oceanic cosmopolite, in Africa: Canaries, Kil, SE-Zre, Swz, Tvl, Nat, Cape, Mad, Réu).

Cephaloziella kiaerii (Aust.) S. Arn. — 1: 11731/C, det. J. Váňa (Southeast African: Cape, Nat, Tvl, Moz).

Jungermannia borgenii Gott. — 1: 11734/C, det. J. Váňa (Afromontane: Cam, Nig, S—T, Congo, Zre, Z, Uga, K, T, Rwa, Mal, Botswana, Ang, SAf, Mad, Réu, Mau).

Jungermannia sphaerocarpa Hook. — 1: 11731/A, det. J. Váňa (Holarctic, in Africa altimontane: Cam, Muh, Niragongo, Elg, Ruw, Kil, Mad, Réu).

Plagiochila crispulo-caudata Gottsche — 3: 11629 (South-east African: Cape, Nat, Tvl, Rho, Mal: Zomba Mts., E-Zre, Ulu, Mad).

Plagiochila heterostipa Steph. — 1: 11745 (South-east African: Cape, Nat, Tvl, Swz, Rho, Ang, S and E Zre, Mal: Zomba Mts., Shire Hlds, Mul; Bur, Mad).

Plagiochila lastii Mitt. — 1: 11756 (East African montane element: Uga, Ken, Rwa, Kil, WUs, Usa, Mul, Tvl).

Radula boryana (Web.) Nees — 2: 11796/A (Pantropical).

Frullania angulata Mitt. — 3: 11627, det. C. Vanden Berghen (Afromontane: S-T, F-P, Ann, Cam, Zre, Ang, Mer, Kil, Usb, Por, Mad).

Frullania arecae (Spreng.) Gottsche — 3: 11625, det. C. Vanden Berghen (Pantropical).

Frullania serrata Gottsche — 2: 11790/B (Palaeotropical, in Africa: Cape, Nat, Tvl, Rho, Zre, Ulu, Usb, Kil, Kas).

Aphanolejeunea capensis (S. Arnell) S. Arnell — 2: 11796/B, on leaves and stems of *Radula boryana* (South African: Cape, Tvl).

Microlejeunea africana Steph. — 2: 11796/C, on *Radula boryana* (Afromontane, widespread in tropical and South Africa).

Symphyogyna podophylla (Thunb.) Nees et Mont. — 2: 11770 (Pantropical, widespread in tropical and in South Africa).

Asterella wilmsii (Steph.) S. Arn. — 1: 11738, det. R. Grolle (South African: Cape, Nat, Tvl, Swz, Rho, Moz, Mad?).

MUSCI

Fissidens asplenioides Hedw. — 2: 11798 (Pantropical).

Fissidens ovatus Brid. var. **ochroloma** Ren. et Card. — 1: 11755 (Disjunct African element: Açores, South Africa, East Africa, Mascarenes).

Fissidens plumosus Hornsch. — 1: 11746 (South-east African: Cape, Tvl, Rho: Inyanga; Ulu).

Dicranella subsubulata (Hpe) Jaeg. — 2: 11784 (South-east African: Cape, Nat, Rho: Inyanga, Ulu).

Campylopodium euphorocladum (C. Müll.) Besch. — 2: 11771/A (Palaeotropical, in Africa only: Abe, Kil).

Campylopus flaccidus Ren. et Card. fo.n. **epilosa** Bizot — 2: 11775. A typo differt foliis apicibus sine acumine hyalino, cellulis tenuibus (Holotype: 0). (The species is known only from Madagascar: Betsileo.)

Campylopus inchangae (C. Müll.) Par. — 1: 11737, 11758; 2: 11767 (South-east African: Cape, Nat, Tvl, Rho, Mal, Moz).

Campylopus polytrichoides De Not. — 1: 11726/A; 2: 11767/B (Oceanic cosmopolite).

Leucoloma albocinctum Ren. et Card. — 2: 11769 (Known only from Madagascar and from the St. Marie Island).

Leucoloma aspericuspes P. Varde — 2: 11794, 11797 (East African montane element: Ken, WUs, Kan, Ulu).

Leucoloma holstii Broth. — 1: 11732 (East African montane element: WUs).

Leucobryum acutifolium Broth. — 1: 11728/A (South-east African: Nat?, Usa, Mad).

Leucobryum cucullatum Broth. — 1: 11728 (EAf montane: Usb).

Didymodon afro-rubellus Broth. et Wag. ex Dix. — 1: 11739 (South African: Nat).

Hyophila cyathiformis (Dix.) Sim. — 1: 11747 (South-east African: Cape, Nat, Tvl, Rho, Z).

Brachymenium acuminatum (Hedw.) Kindb. — 2: 11786, 11787 (Pantropical).

Bryum alpinum Rehm. ex C. Müll. — 2: 11782 (Cosmopolite).

Bryum argenteum Hedw. var. **lanatum** (P. Beauv.) Hampe — 2: 11789 (Cosmopolite).

Philonotis hastata (Dub.) Wijk. et Marg. — 2: 11771, 11785 (Pantropical).

Breutelia gnaphalea (P. Beauv.) Mitt. — 1: 11725, det. J.-L. De Slover. A Malgassian species already published from the Lichenya Plateau by E. B. Bartram (1953: 194) with a question mark.

Schlotheimia laetevirens Broth. — 3: 11628 (EAf montane: Usb).

Calyptothecium hoehnelii (C. Müll.) Argent. Syn.: *Renauldia hoehnelii* (C. Müll.) Broth. — 2: 11763 (Widespread in East and in South Africa).

Pilotrichella ampullacea (C. Müll.) Jaeg. — 1: 11733, 11747; 2: 11791 (EAf montane: Abe, Ken, Kil, Usb, Kan, Ulu, Shl, Comores).

Papillaria africana (C. Müll.) Jaeg. — 1: 11750; 2: 11779 (Tropical African, widespread).

Aerobryidium subpiligerum (Hpe.) Card. — 1: 11757 (EAf montane: Kil, EUs, Ulu, SHl, Mad, Réu, Comores).

Porothamnium hildebrandtii (C. Müll.) Fleisch. — 1: 11735/B (Widespread in tropical and in South Africa).

Hypopterygium mildbraedii Broth. — 1: 11749 (EAf montane: Elg, Kar, Kil, Ulu).

Hypopterygium viridissimum C. Müll. — 1: 11751; 2: 11793 (Widespread in tropical America and in Africa).

Ectropothecium regulare (Brid.) Jaeg. — 2: 11798 (Tropical African: Cam, Gab, Zre, EUs, Ulu, Cape, Nat, EAf islands).

Hypnum aduncoides (Brid.) C. Müll. — 2: 11788 (Palaeotropical: Cape, Nat, Tvl, Mad, Réu, India).

Atrichum androgynum (C. Müll.) Jaeg. — 1: 11735/A (South-east African: Cape, Nat, Zul, Tvl, Rho).

Polytrichum commune Hedw. — 2: 11768 (Cosmopolite).

The above specimens are deposited in the herbaria of O, EGR and some mosses in the herbarium of Professor M. BIZOT.

Phytogeographical distribution

The 60 species were analysed as to geographical distribution:

South-east African elements:	10 species, of which 3 also occur in Madagascar
South African elements:	4 species
East African montane:	9 species
Afromontane	3 species
Afroalpine:	2 species
Tropical African:	4 species
Madagascan (Malgassian)	3 species
Palaeotropical:	7 species
Neotropical:	1 species
Pantropical:	7 species
Cosmopolitan elements:	7 species, of which 4 with oceanic character
Holarctic:	1 species
Subantarctic:	1 species
Disjunct:	1 species
	60 species

The geographical position of the Mulanje Mountains is of course reflected in the high number of South-east African species. However, there are also important East African montane and alpine elements, besides some South African species. This pattern of distribution has analogues among the higher plants. Thus, within the *Cupressaceae* these mountains are the meeting place of the South African genus *Widdringtonia*, represented by the endemic *W. whytei*, and of the northern *Juniperus excelsa*, widespread in the East African mountains (KERFOOT 1975: 147). The two afroalpine species: *Campylopus procerus* (C. Muell.) Par. and *Trachypodopsis laxoalaris* Broth. have in Malawi an isolated occurrence (see BIZOT and PÓCS 1974: 419, 431). The presence of Malgassian elements, like *Campylopus flaccidus* Ren. et Card., *Leucoloma albocinctum*

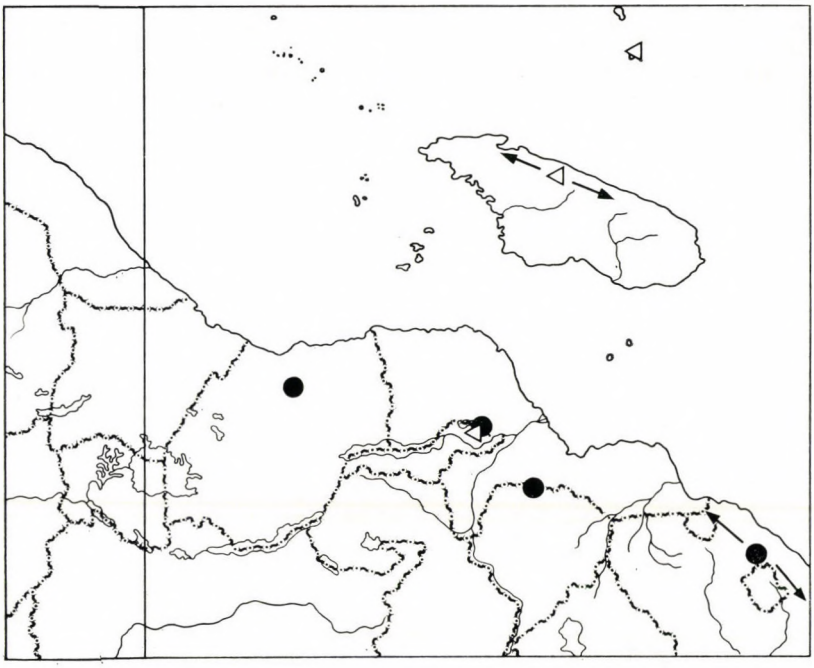


Fig. 4. Distribution of a South-east African element: *Dicranella subsubulata* (Hpe.) Jaeg. (full circle) and of a Malgassian element: *Breutelia gnaphalea* (P. Beauv.) Mitt. (triangle)

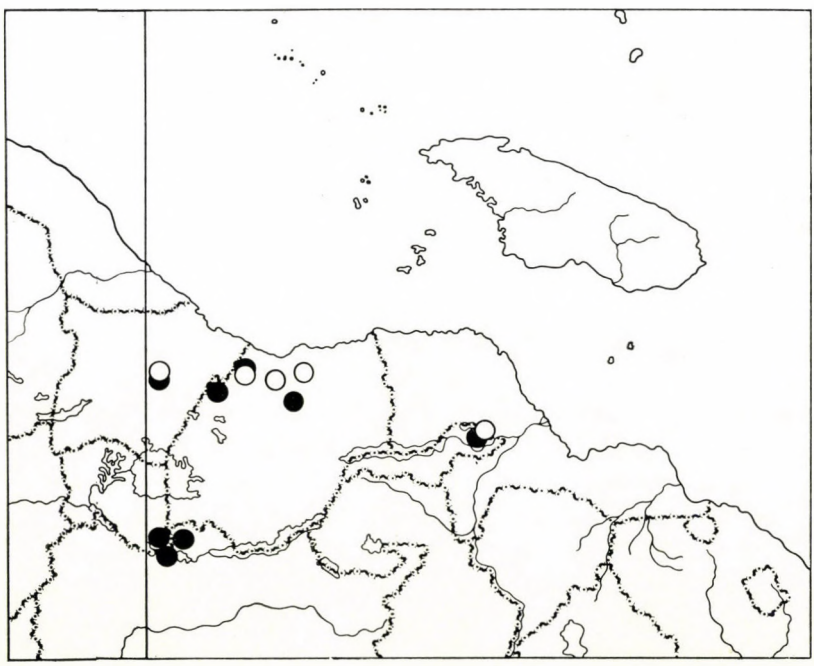


Fig. 3. Distribution of East African montane elements: *Plagiochila lastii* Mitt. (full circle) and *Leucoloma aspericuspis* P. Varde (open circle)

Ren. et Card. and *Breutelia gnaphalea* (P. Beauv.) Mitt., in the old crystalline massifs in East Africa has a great significance from the historical point of view, as discussed by Pócs (1975: 127—128). Their rôle in the Mulanje Mountains seems less important than in the mountains of Eastern Tanzania.

REFERENCES

BARTRAM, E. B. (1953): Musci. In J. P. M. BRENAN and collaborators: Plants collected by the Vernay Nyasaland Expedition of 1946. Mem. N. Y. Bot. Gard. **8,** 191—197.

BIZOT, M.—PÓCS, T. (1974): East African Bryophytes, I. Acta Acad. Paed. Agriensis, Eger, n. ser. **12,** 383—449.

CHAPMAN, J. D.—WHITE, F. (1970): The evergreen forests of Malawi. Oxford, 190 pages + 45 plates.

KERFOOT, O. (1975): Origin and speciation of the Cupressaceae in Sub-Saharan Africa. Boissiera **24,** 145—150.

PÓCS, T. (1975): Affinities between the bryoflora of East Africa and Madagascar. Boissiera **24,** 125—128.

POTIER DE LA VARDE, R. (1958): Contribution à la flore bryologique africaine (11e article). Rev. Bryol. et Lichén. **27,** 139—144.

THÉRIOT, I. (1931): Quelques mousses de Nyassaland. Rev. Bryol. et Lichén. **4,** 75—77.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1—2), pp. 9—16 (1976)

THERMOLABILE AND THERMOSTABLE INTERPHASES IN THE VERNALIZATION OF WINTER WHEAT (TRITICUM AESTIVUM VAR. BÁNKÚTI 1201)

By

M. Dévay, E. Páldi and I. Kovács

AGRICULTURAL RESEARCH INSTITUTE, HUNGARIAN ACADEMY OF SCIENCES, MARTONVÁSÁR

(Received March 12, 1976)

The number of thermostable and thermolabile interphases brought about by the vernalization of winter wheat (*Triticum aestivum* var. *Bánkúti 1201*) has been examined by means of "kinetic analysis" experiments using vernalization, devernelization and revernelization.

The development-accelerating effect of vernalization can be reversed by 36 hours' treatment at 32°C. The successfulness of devernalization depends on the duration of the foregoing vernalization. The data suggest that several thermostable and thermolabile interphases occur in the course of the vernalization of winter wheat. The complete reversibility during the early stages of vernalization indicates that the processes which take place at the beginning of vernalization, and also their end-products, are sensitive to temperature. After this the first thermostable interphase may come into existence, followed by yet another thermolabile phase. The thermostable end-phase is formed after vernalization, and simultaneously indicates the stabilization of the vernalization effect. The approximate position of the thermostable interphase in the course of vernalization also has been discussed.

Introduction

The word "morphogenesis" means in general the organization of certain organ. The authors agree with Bopp (1963) that morphogenesis should be considered to include all the processes of developmental morphology which result in differentiation. Therefore, not only the appearance of the growing organs, but also the processes which prepare for or make possible this growth may be classified as morphogenesis. These processes are influenced by certain external and internal factors.

Naturally this immediately raises the question of what connection there is between the mechanisms affected by ecological factors and those provoking morphogenetic processes. The reaction system produced by environmental effect can only be directly connected with the morphogenesis in exceptional cases. In most cases it causes the formation of such functions as result in responses by initial cells (Bopp 1963). From this viewpoint the mechanism controlled by external environmental conditions can be interpreted as a locking system which opens and closes one or more channels. What flows through these channels depends on the genetic characteristic of the cell (Mohr—Ohlenroth 1962).

The investigation of one of the fundamental phases of morphogenesis — the transition from the vegetative to the reproductive stage — has been in progress for a long time, and considerable progress has been made in recent decades. Of exceptional interest in this respect is the clarification of the process concerning the accelerated induction of ripeness to flower by exposure to cold in cold-requiring plants. This process, which ranks without doubt as one of the most interesting problems of morphogenesis, is known as vernalization. Vernalization is essentially the acceleration of plant development due to the cold effect. It is a prerequisite for flower formation and makes the plants "capable of responding to the photoperiod".

It is a significant paradox of vernalization that an environmental condition, low temperature, which generally reduces the intensity of physiological processes, exerts a favourable effect upon one of the stages in plant development.

The greatest vernalization effect is usually achieved by employing temperatures immediately above the freezing point of water. In cereals, the lower limit for the active vernalization temperature is generally —3°C and the upper limit 10°C (RAZUMOV 1961). The temperature range 10—20°C is neutral, exhibiting no vernalization effect. The cold-induced "ripeness to flower" can, in the majority of cold-requiring plants, be annulled under certain conditions by the action of heat (about 3 days at 25—40°C). This phenomenon is called devernalization. Devernalization is not able to produce a permanent state. This is confirmed by the renewed vernalizability at low temperature of plants devernalized by heat. This renewed vernalization of devernalized plants is known as revernalization. (GREGORY—PURVIS 1945, 1948, EFEYKIN 1947, RAZUMOV 1950, FRIEND—PURVIS 1963, NAPP-ZINN 1953, 1957).

Attempts to compile a mechanism for vernalization have been based primarily on the temperature-dependences of the vernalization, devernalization and revernalization processes. The experiments which have been carried out under the heading of "kinetic analysis" have at last provided an explanation for the paradoxical situation which exists for vernalization. The key to the situation lies in the fact that thermolabile and thermostable intermediate stages are involved in the process.

The satisfaction of the cold requirement may be provisionally described as a reaction A → B. B characterizes the end-product of vernalization and may include the existence of a certain flowering hormone, or of its precursor, or of an enzyme or group of enzymes which is able to synthesize the substances that control the flower initiation even at higher temperatures. If it is missing from the system, e.g. from cold-requiring plants B can only be synthesized at low temperatures, probably in several steps. PURVIS (1961) designated these preceding steps as Á and postulated that in the actual low temperature stage only the change A → Á takes place. This proved to be reversible at high tem-

peratures, thus devernalization and revernalization are possible. Other authors (MELCHERS 1952, FRIEND—PURVIS 1963) postulate a threefold reaction with various temperature dependencies. The vernalization process can be described by the following formula:

$$\text{A precursor} \xrightarrow{\text{I}} \text{intermediate products} \begin{cases} \xrightarrow{\text{II}} \text{B end-products} \\ \xrightarrow{\text{III}} \text{temperature damage to the intermediate products} \end{cases}$$

where process III, which represents the decomposition of thermolabile intermediate products at the devernalization temperature, has a higher temperature coefficient than processes I and II. In the course of successful vernalization a thermolabile intermediary product is synthesized, which is capable of reacting in two ways: at low temperatures it is mainly involved in the synthesis of, for example, a hypothetical thermostable flowering hormone such as vernalin, whereas at higher temperatures another process dominates, in which the intermediate product is rendered useless for the synthesis of substances controlling flower initiation. In plants not requiring low temperatures the end-product is either originally present, or its synthesis is ensured even at higher temperatures.

Naturally it is an over-simplification to assume only two competing processes. The real state may be considerably more complicated. The various cold-requiring plants, such as *Hyoscyamus niger*, *Secale cereale* and *Arabidopsis thaliana*, differ in the number of thermolabile and intercalated thermostable stages involved in the process of vernalization (NAPP-ZINN 1973).

In the present paper results concerning the thermolabile and thermostable interphases in the vernalization of winter wheat (*Triticum aestivum* var. *Bánkúti 1201*) are summarized. The number of thermostable and thermolabile interphases brought about by the vernalization of winter wheat has been elucidated in part by means of "kinetic analysis" experiments using vernalization, devernalization and revernalization.

Material and methods

(a) Vernalization, devernalization, revernalization. Seedlings of winter wheat (*Triticum aestivum* var. *Bánkúti 1201*) were used in the experiments. After sterilization in bromine water the seeds were germinated for 36 hours at 20°C. The vernalization of the germs was carried out in a refrigerator, at 0° to −1°C. At this temperature vernalization proceeds at a normal rate with cell division practically at a standstill (DÉVAY 1962). The oxygen required for vernalization was provided by frequent ventilation. The germs were vernalized for 0, 7, 14, 21, 28, 35, 42, 49, 56, 63, 70 and 77 days, respectively. After the vernalization period the germs were devernalized for 0 and 36 hours at 32°C with an unrestricted supply of water. Some of the devernalized germs were then revernalized for 7, 14, 21, 28, 35, 42, 49 and 56 days at 0° to −1°C in a refrigerator.

The vernalized, de- and revernalized germs were planted in perlite and grown in a climatic chamber at 17°C and a light intensity of 85,000 erg cm^{-2} sec^{-1} with continuous light until the appearance of the flower primordia.

(b) Determination of the vernalization effect. There is no specific easily examined property which can be used for the determination of the vernalization effect, since the ripeness to flower produced by the cold treatment does not manifest itself morphologically in the plants. Thus, up to the present time only indirect methods are available for the determination of the vernalization effect. The most commonly used procedures are the so-called "final leaf number" method (PURVIS 1934) and methods which measure the velocity of development.

In our experiments the progress of vernalization was characterized both by the "final leaf number" method, and by the number of days necessary from the end of the treatment to the appearance of flower buds. Five samples were taken from the experimental plant material weekly and the developmental stage of the shoot-tips was determined. After the initiation of spikelet differentiation the interval between samples was shortened to 1—2 days, and the number of plants tested was increased to 25. In this way it proved possible to determine the time when floral primordia appeared to within 2—3 days. The time at which floral primordia had appeared on 50% of the plants was used to diagnose the development-acceleration effect of vernalization.

Results and discussion

Low temperature treatment results in a shortening of development period in *Bánkúti 1201* winter wheat. The number of days necessary before the appearance of floral primordia in non-vernalized plants is 230, as compared to 44 in those which are completely vernalized. In germs vernalized at 0° to —1°C (Fig. 1) 49 days are necessary for the complete satisfaction of the cold requirement (i.e. until further cold treatment is ineffective in shortening the time required before the appearance of floral primordia).

Compared to the non-vernalized control the final leaf number (i.e. the number of leaves formed on the main shoot before heading) decreased under the influence of vernalization (Fig. 1). The shortening of the time necessary for flower initiation and the decrease in final leaf number, taken as a function of vernalization level, both give S-shaped curves.

The development-accelerating effect of vernalization can be reversed by 36 hours' treatment at 32°C. The successfulness of devernalization depends on the duration of the foregoing vernalization. The reversibility of the vernalization effect was variable; it could be reversed more completely at the beginning of the vernalization treatment (Table 1).

The complete reversibility demonstrated in winter wheat (TETYUREV 1941) could be observed here only during the first half of the vernalization, after 7, 14 and 21 days' cold treatment. Following this successful devernalization the plants can be revernalized by a renewed cold treatment. The time required for the revernalization was the same as that required for vernalization itself under normal conditions. During the second half of vernalization the devernalizability decreases stepwise. After 28, 35, 42 and 49 days' cold treatment the number of days necessary before the appearance of floral primordia remained almost constant, irrespective of the duration of the foregoing vernalization and a uniform 16 days' revernalization was required. A prolonged cold

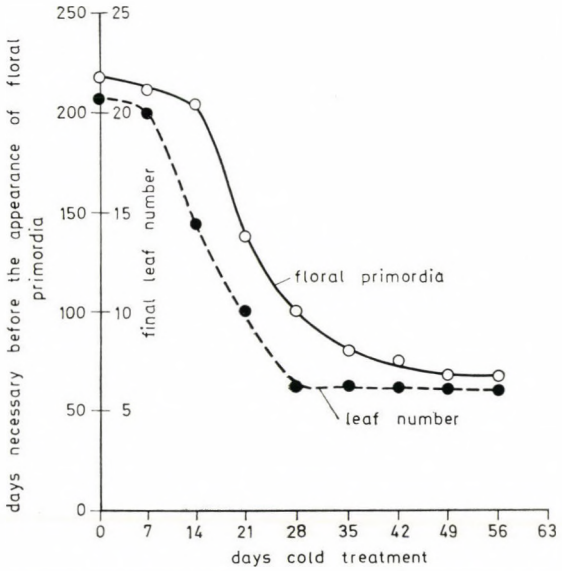


Fig. 1. Cold-induced acceleration of the "ripeness to flower" in winter wheat (*T. aestivum* var. *Bánkúti 1201*). Germs vernalized in a refrigerator at 0° to −1°C were planted in perlite and grown in a climatic chamber at 17°C at a light intensity of 85,000 erg cm^{-2} sec^{-1} with continuous light until the appearance of the floral primordia or until the earing. The progress of vernalization was characterized by the number of leaves formed on the main shoot before earing (i.e. final leaf number) as well as by the number of days necessary from the end of cold treatment to the appearance of floral primordia (i.e. days necessary to flower initiation)

Table 1

Correlation between the devernalizability of winter wheat (Triticum aestivum var. *Bánkúti 1201) and the foregoing vernalizing effect of cold treatment*

Duration of the foregoing vernalization in days		Number of days necessary before the appearance of floral primordia			Residual effect equivalent ... days cold treatment	Time required for complete revernalization in days
		not devernalized $\bar{x}$	devernalized $\bar{x}$	$\pm$		
Vernalization	0	232	233	3.5	0	48—50
	7	225	233	3.5	0	48—50
	14	217	228	3.0	0	48—50
	21	174	228	3.0	0	48—50
	28	100	110	2.5	24	18
	35	60	90	2.5	29	16
	42	50	89	2.0	30	16
	49	44	85	1.5	31	16
Stabilization	56	43	83	1.5	31	16
	63	44	83	1.5	31	16
	70	43	46	1.5	45	5
	77	44	43	1.5	49	0

treatment of the variety further decreased the devernalizability, and after 11 weeks high temperature was without effect (Table 1).

The devernalization ability cannot be increased even by means of a longer devernalization period. Heat treatment longer than 36 hours had no further influence on the degree of devernalization (Table 2).

Table 2

The effect of prolonged heat treatment on the devernalizability of fully vernalized winter wheat (Triticum aestivum var. *Bánkúti 1201)*

Duration of the heat treatment in hours	Number of days necessary before the appearance of floral primordia		Time required for revernalization in days
	$\bar{x}$	±	
0	44	1.5	10
24	81	1.5	16
36	80	1.5	16
48	82	1.5	16
72	83	1.5	16

The data suggest that some thermostable and thermolabile interphases occur in the course of the vernalization of *Bánkúti 1201* winter wheat. The complete reversibility at the beginning of the vernalization indicates that the processes which take place at the beginning of vernalization, and also their end-products, are sensitive to temperature. After this the first thermostable interphase may come into existence, followed by yet another thermolabile phase. The thermostable end-phase is formed after the vernalization, and simultaneously indicates the stabilization of the vernalization effect.

On the basis of the time required after devernalization for successful revernalization, together with a knowledge of the number of days necessary before the appearance of floral primordia in partially vernalized and devernalized plants, it is possible to deduce the approximate position of the thermostable interphase.

Under normal conditions (Fig. 1) after 24 days' cold treatment the number of days necessary for the formation of floral primordia is 160, and a developmental period of 90 days is required after 30 days' exposure to low temperature. Plants vernalized for 35, 42 and 49 days, if devernalized for 36 hours at 32°C, needed about 90—160 days from the end of temperature treatment to the appearance of flower buds (Table 1). This time was equivalent to that required before the appearance of floral primordia in plants vernalized for 23—30 days. The number of days generally required for full revernalization in these cases was 16—18. From the partially devernalizing effect, and from the fact that the plants required a shorter cold treatment for

revernalization, as mentioned above, it may be inferred that the thermostable interphase is formed approximately between the 20th and 30th days of vernalization. Naturally these values are given as a rough approximation.

It is certain, however, that, apart from the final stabilization process, 2 thermolabile and one thermostable phase can be expected during the vernalization of winter wheat (Fig. 2).

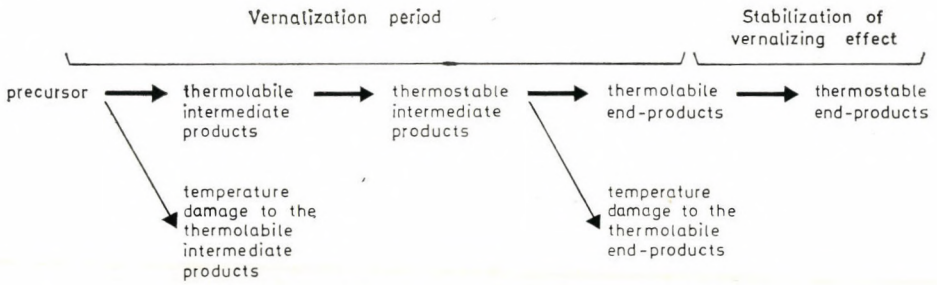


Fig. 2. The approximate position of thermostable and thermolabile interphases in the course of vernalization

The individual phases may consist of one or more series of reactions. Thus the vernalization of *Bánkúti 1201* winter wheat is not fundamentally a single process, but, on the contrary, it consists of several phases connected by periods relatively insensitive to temperature.

It is probable that the winter wheat varieties differ in the number of thermolabile and thermostable intermediate stages involved in vernalization, as well as in the stabilization of the vernalization effect. The character of thermolabile and thermostable interphases in the course of vernalization in winter wheat cultivars is still not known in detail, so a great deal of further research work is needed. These experiments can throw light not only on plant development, but also on such important factors as frost resistance and the earliness of the varieties. An exact knowledge of these mechanisms is important when determining both the orientation of a selectional programme and criteria of selection.

REFERENCES

Bopp, M. (1963): Über die innere Steuerung der Morphogenese bei höheren Pflanzen. Ber. Dtsch. Bot. Ges. **75,** 64—77.

Dévay, M. (1962): Biochemical processes in vernalization. I. Symp. on Genetics and Wheat Breeding. Martonvásár, Hungary, 17—40.

Efeykin, A. K. (1947): K voprosu ob obratimosti processa jarovizacii. DAN. SSSR. **56,** 96—98.

Friend, D. J. C.—Purvis, O. N. (1963): Studies in vernalization of cereals. XIV. The thermal reactions in vernalization. Ann. Bot. (NS) **27,** 553—579.

Gregory, F. G.—Purvis, O. N. (1938): Studies in vernalization of cereals. II. The vernalization of excised mature embryos and developing ears. Ann. Bot. (NS) **2,** 338—351.

GREGORY, F. G.—PURVIS, O. N. (1945): Devernalization by high temperature. Nature (London) **155,** 113—114.

GREGORY, F. G.—PURVIS, O. N. (1948): Reversal of vernalization by high temperature. Nature (London) **161,** 859—860.

MELCHERS, G. (1952): The Physiology of Flower Initiation. Dokumentumstelle der M.P.G. Göttingen.

MOHR, J.—OHLENROTH, H. (1962): in BOPP 1963.

NAPP-ZINN, K. (1953): Thermostabile and thermolabile Zwischenstadien im Vernalisationsprozess. Ber. Dtsch. Bot. Ges. **46,** 362—368.

NAPP-ZINN, K. (1957): Physiologische Analyse des Vernalisationsvorganges. Zeitschrift für Bot. **45,** 320—333.

NAPP-ZINN, K. (1973): Low Temperature Effect on Flower Formation. In PISEK, A.—LARCHER, W.—VEGIS, A.—NAPP-ZINN, K.: The Temperature and Life. Springer Verlag, Berlin—Heidelberg—New York, 171—194.

PURVIS, O. N. (1934): An analysis of the influence of temperature during germination on the subsequent development of certain winter cereals and its relation to the effect of length of day. Ann. Bot. **48,** 917—955.

PURVIS, O. N. (1961): The physiological analysis of vernalization. Encyclopedia of plant physiology. Springer Verlag, Berlin—Heidelberg—New York, 16, 76—122.

PURVIS, O. N.—GREGORY, F. G. (1937): Studies in vernalization of cereals. I. A comparative study of vernalization of winter rye by low temperature and short days. Ann. Bot. (NS) **1,** 567—592.

RAZUMOV, V. I. (1950): K itogam rabot po tak nazivaemoj "raz" jarovizacii. Agrobiologija, 27—34.

RAZUMOV, V. I. (1961): Sreda i razvitie rastenij. Izd. Selskohoz. Lit. Leningrad—Moskva, 62—93.

TETYUREV, V. A. (1941): How long can vernalized winter wheat plants treated with high temperature without affecting their development. DAN SSSR **30,** 189—190.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1—2), pp. 17—28 (1976)

INVESTIGATION OF THE K-, Ca-, P-, N- AND AMINO ACID CONTENT OF THE EPIPHYTIC HYPNUM CUPRESSIFORME*

L. DÉZSI and T. SIMON

DEPARTMENT OF PLANT TAXONOMY AND ECOLOGY, EÖTVÖS L. UNIVERSITY, BUDAPEST

(Received February 3, 1976)

As a part of the epiphytic moss-phytomass investigations carried out by the authors in the area of the "Síkfőkút Project" (SIMON 1974), the K-, Ca-, P-, N- and amino acid content of *Hypnum cupressiforme* has now also been studied. The authors determined the amount of these elements in the living and dead fractions of the moss and in the substrate bark. Taking into consideration and converting the dry weight of epiphytic *Hypnum* cushions falling to the unit area of 200 sq.m, the estimated values for one hectare are the following: about 300 g potassium, 260 g calcium, 150 g phosphorus, 780 g nitrogen and 260 g amino acid.

On the inner content of mosses (macro- and micro-elements, several organic compounds, esters, sucrose alcohols, enzymes, amino acids, etc.) continually new information is revealed by chemical analysis (TAMM 1954, SMITH 1955, HUNECK 1969, 1972, MATSUO et al. 1972, LEWIS 1971, ERAMETSA—YLIRUOKANEN 1971, BENDZ—SVENSSON 1971, SUIRE 1975, etc.). The ecology of epiphytic mosses and the chemical composition of their substratum are fully discussed in the summarizing work of BARKMAN (1958). On the basis of the above experiences — and taking into consideration the nutrient uptake on the whole body surface of mosses — one may assume that these elements have a special role in the material production of the producent subsystem of ecosystems, and in its material and energy cycle.

To explore the details of this problem, a multi-stage investigation was planned. In 1973 we studied the moss cover of tree trunks within the turkey-oak forest model area called "Síkfőkút-Project" (JAKUCS 1973) near Eger, in an area covering 200 sq.m (*Quercus petraea* ssp. *dalechampii*). The specific composition of the moss covers, their total surface and weight, and the cover and weight for each species and trunk were determined (SIMON 1974). The major part (49.736 sq.cm), that is 94 per cent of the epiphytic moss cover (52.969 sq.cm) falling to the given area, is composed of *Hypnum cupressiforme*. Concerning weight, this value is even more significant, because 97 per cent of the total cover (i.e. 798.99 g) falls to *Hypnum cupressiforme*.

Taking into consideration the above, an investigation of the K-, Ca-, P-, N- and amino acid content of the *Hypnum*-cushions was planned. It is

* "Síkfőkút Project" No. 16

our opinion that within the producent layer of the ecosystem it may be useful to study the special epiphytic compartments, concerning matter turnover. This epiphytic "compartment" functions with its vast surface partly as a filter and partly as a storer of matter in the given forest ecosystem.

Material and method

The epiphytic moss samples used in the course of chemical investigations originated from the material collected (SIMON 1974) — for the purpose of phytomass investigations — in the model area called "Síkfőkút Project" near Eger. The so-called mesotypical samples thickness group No. 1, SIMON l. c.) originated from the very bottom of the moss cover. The so-called xerotypical samples (thinner cover — thickness group No. 2, SIMON l. c.) were collected directly above the former ones. To sum up: three kinds of samples were undergoing chemical analysis: xerotypical mosses collected in January (thickness group No. 2), mesotypical mosses collected in January (thickness group No. 1) and mesotypical mosses sampled in May (thickness group No. 1).

For chemical investigation, the air-dry plant material was ground to dust, each 200 g was put into destruction test-tubes and destructed with 2 ml of cc H_2SO_4. To accelerate destruction, to the material being in the state of boiling, 0.5 ml of $HClO_4$ was added. Having finished destruction, the material was diluted with distilled water to the amount of 20 ml, and the total N-, P-, K- and Ca-content of the solution was determined. Nitrogen was determined by means of the Nessler-reaction, P by a procedure using molybdenum-sulphuric acid, while as a reducing material eiconogene was used. The coloured solutions — obtained in the course of reactions — were measured by the help of a spectrophotometer. The amounts of K and Ca were determined by using a flame-photometer. Besides the above-mentioned elements, also the total amino acid content and the amino acid composition of the moss and the bark were investigated. For the purpose of this investigation (according to the method of PÁLFI, 1970), 200 mg plant material was crumbled and centrifuged (8000 r.p.m.). The floating solution was distilled and the sediment solved in 2 ml fifty per cent ethylalcohol. 0.5 ml of this solution was applied to chromatogram paper and chromatographed in a compound of butanol—acetic acid—water (proportions 4 : 1 : 1), unwarmed, at 3°C. The chromatogram was developed by means of ninhydrin, at 65°C.

To determine the total amino acid content, amounts of 0.05 ml of the extracts and standard solutions were applied to the chromatogram paper showing circlets with a diameter of 3 cm. The chromatogram was developed by the help of cadmium-ninhydrin, at 80°C, in 20 minutes. The patches were eluated in 5 ml fifty per cent methanol. The obtained coloured solution was measured by a spectrophotometer 402 MOM, at 520 millimicrons.

The elaboration of the obtained data (mean value, errors of mean values), the comparison of mean values, the evaluation of the reliability of differences (t-test) were done by the usual mathematical-statistical methods (SVÁB 1973). In the course of the conversion into unit areas of the K-, Ca-, P- and N-content of the January moss samples (living and dead fractions), the phytomass data obtained earlier (SIMON 1974) were used. Since the samples belonging into thickness group No. 3 (SIMON l., c., p. 346, Table 3) were not elaborated, the probable K-, Ca-, P-, N- and amino acid content of these was estimated on the basis of the experiences of our present data (= 7.25 mg/air-dry material, Ca = 4.58 mg/air-dry material, P = 3.14 mg/air-dry material, N = 6.40 mg/air-dry material, amino acid = 4.21 mg/air-dry material).

Results

Potassium appeared in all three groups predominantly in the plant as compared to the K-content of the bark (Table 1). Within the plant, the highest K-content was always found in the living fraction. The K-content of the thinner (xerotypical) and thicker (mesotypical) samples collected in January

Table 1

K-, Ca-, P- and N-content (mg/1g dry weight) of epiphytic Hypnum cupressiforme covers, their mean values and the errors of mean values ($s_{\bar{x}}$)

	K			Ca			P			N		
	n	Mean $\bar{x}$	$s_{\bar{x}}$	n	Mean $\bar{x}$	$s_{\bar{x}}$	n	Mean $\bar{x}$	$s_{\bar{x}}$	n	Mean $\bar{x}$	$s_{\bar{x}}$
Hypnum cupressiforme I/2												
living	7	4.10	0.40	6	2.73	0.12	18	1.99	0.02	18	10.17	0.35
dead	7	3.32	0.24	6	3.48	0.66	18	1.60	0.02	18	7.67	0.45
bark	7	1.16	0.15	6	11.06	2.86	18	1.08	0.08	18	5.58	0.31
Hypnum cupressiforme I/1												
living	7	4.04	0.06	7	2.87	0.11	9	2.27	0.05	15	15.94	0.53
dead	7	3.55	0.14	7	4.97	0.71	9	1.77	0.05	15	13.34	0.54
bark	7	4.08	0.22	7	7.44	1.16	9	1.12	0.14	15	15.10	0.27
Hypnum cupressiforme V/1												
living	4	3.00	0.08	4	2.32	0.17	3	2.39	0.08	12	13.96	0.93
dead	4	2.37	0.20	4	3.47	0.16	3	1.90	0.07	12	12.97	1.21
bark	4	0.76	0.10	4	12.87	1.52	3	0.52	0.00	12	8.21	0.53

proved to be nearly similar, but the potassium content of the bark was considerably higher underneath the thicker cushions (Table 2). If we compare the January xerotypical and the mesotypical samples of May, we find that the amount of K is always higher in the xerotypical covers, and more significantly so if the living and dead fractions are regarded (Table 3). Comparisons of the mesotypical samples of January samples contain a significantly higher amount of potassium (Table 4). Making a comparison between the xerotypical samples of January and the contracted values of the mesotypical samples (of January and May), one can see that the high K-content of the xerotypical living and dead fractions shows a slight overweight, while the bark has a significantly higher potassium content underneath the mesotypical cushions (Table 5).

To sum up, it may be stated that potassium is accumulated in the plant. It remains under more extreme conditions in the epiphytic cover, while under more balanced conditions it may penetrate into the surface layers of the bark. Thus the higher K-content of the moss cover is a property of xerotopic conditions. The current situation of potassium in this epiphytic vegetation is probably corresponding to the changes of climatic elements. BREHM (1971) made a similar observation in the course of investigation of the ion exchange in *Sphagnum* hummocks. It is probable that potassium originates, first of all, from the precipitation water flowing down the trunk and having a significant K-content (SZABÓ 1976).

The amount of *calcium* is generally higher in the bark, or the Ca-content of the moss and of the bark is approximately identical (Table 1). Within the

Table 2

Comparative evaluation of the K-, Ca-, P- and N-content (mg/air-dry substance) of samples I/2 and I/1 of Hypnum cupressiforme

	Living		Dead		Bark	
	Hypnum I/2	*Hypnum* I/1	*Hypnum* I/2	*Hypnum* I/1	*Hypnum* I/2	*Hypnum* I/1
			K			
$\overline{X}$	4.10	4.04	3.32	3.55	1.16	4.08
$\overline{X}_1-\overline{X}_2$	0.06		0.23		2.92	
t	0.15		0.81		10.81	
$t_{5\%}$	2.18		2.18		2.18	
$SD_{5\%}$	—		—		0.59	
			Ca			
$\overline{X}$	2.73	2.87	3.48	4.97	11.06	7.44
$\overline{X}_1-\overline{X}_2$	0.14		1.49		3.62	
t	0.82		2.63		1.42	
$t_{5\%}$	2.18		2.20		2.20	
$SD_{5\%}$	—		5.78		—	
			P			
$\overline{X}$	1.99	2.27	1.60	1.77	1.08	1.12
$\overline{X}_1-\overline{X}_2$	0.28		0.17		0.04	
t	5.41		3.69		0.26	
$t_{5\%}$	2.06		2.79		2.06	
$SD_{5\%}$	0.10		0.09		—	
			N			
$\overline{X}$	10.17	15.94	7.67	13.34	5.58	15.10
$\overline{X}_1-\overline{X}_2$	5.77		5.67		9.52	
t	7.87		2.25		22.90	
$t_{5\%}$	2.04		2.04		2.04	
$SD_{5\%}$	1.43		5.12		0.87	

above parts, the Ca-content of the dead fraction of the plant is always higher than that of the living fraction! The comparison of the January xerotypical and mesotypical samples shows that the Ca-content of the mesotypical *Hypnum* is higher (in the dead fraction even significantly higher) than that of the xerotypical *Hypnum*. The bark shows, however, a higher Ca-content underneath the latter (Table 2). The Ca-contents in the xerotypical samples of January and

Table 3

Comparative evaluation of the K-, Ca-, P- and N-content (mg/air-dry substance) of samples I/2 and V/1 of Hypnum cupressiforme

	Living		Dead		Bark	
	Hypnum I/2	*Hypnum* V/1	*Hypnum* I/2	*Hypnum* V/1	*Hypnum* I/2	*Hypnum* V/1
			K			
$\overline{X}$	4.1	3.0	3.32	2.37	1.16	0.76
$\overline{X}_1-\overline{X}_2$	1.1		0.95		0.40	
t	2.71		2.62		1.80	
$t_{5\%}$	2.47*		2.26		2.26	
$SD_{5\%}$	1.00		0.82		—	
			Ca			
$\overline{X}$	2.73	2.32	3.48	3.47	11.06	12.87
$\overline{X}_1-\overline{X}_2$	0.41		0.01		1.81	
t	1.78		0.01		0.33	
$t_{5\%}$	2.31		2.31		2.31	
$SD_{5\%}$	—		—		—	
			P			
$\overline{X}$	1.99	2.39	1.60	1.90	1.08	0.52
$\overline{X}_1-\overline{X}_2$	0.40		0.30		0.56	
t	75.47		5.66		2.71	
$t_{5\%}$	2.09		2.09		2.09	
$SD_{5\%}$	0.01		0.11		0.43	
			N			
$\overline{X}$	10.17	13.96	7.69	12.97	5.58	8.21
$\overline{X}_1-\overline{X}_2$	3.79		5.28		2.63	
t	4.36		4.67		4.54	
$t_{5\%}$	2.05		2.05		2.05	
$SD_{5\%}$	1.78		2.32		1.19	

in the mesotypical samples of May (resp. in their fractions) are nearly identical (Table 3). It is to be seen from the comparison of the mesotypical samples of January and May that in January there is more Ca in the plant (living and dead fractions) than in the bark, while in May the situation is the reverse (Table 4). Comparing the data of January xerotypical samples with the con-

Table 4

Comparative evaluation of the K-, Ca-, P- and N-content (mg/air-dry substance) of samples I/1 and V/1 of Hypnum cupressiforme

	Living		Dead		Bark	
	Hypnum I/1	*Hypnum* V/1	*Hypnum* I/1	*Hypnum* V/1	*Hypnum* I/1	*Hypnum* V/1
			K			
$\overline{X}$	4.04	3.00	3.55	2.37	4.08	0.76
$\overline{X}_1-\overline{X}_2$	1.04		1.18		3.32	
t	10.19		4.91		10.64	
$t_{5\%}$	2.26		2.26		2.26	
$SD_{5\%}$	0.23		0.54		0.70	
			Ca			
$\overline{X}$	2.87	2.32	4.97	3.47	7.47	12.87
$\overline{X}_1-\overline{X}_2$	0.55		1.50		5.40	
t	2.81		1.48		2.81	
$t_{5\%}$	2.26		2.26		2.26	
$SD_{5\%}$	0.40		—		4.34	
			P			
$\overline{X}$	2.27	2.39	1.77	1.90	1.12	0.52
$\overline{X}_1-\overline{X}_2$	0.12		0.13		0.60	
t	1.21		1.26		4.37	
$t_{5\%}$	2.23		2.23		2.23	
$SD_{5\%}$	—		—		0.30	
			N			
$\overline{X}$	15.94	13.96	13.34	12.97	8.21	15.10
$\overline{X}_1-\overline{X}_2$	1.98		0.31		6.89	
t	1.79		0.24		12.21	
$t_{5\%}$	2.06		2.06		2.06	
$SD_{5\%}$	—		—		1.16	

tracted values of mesotypical samples (January and May), we find that they are nearly identical (there is no significant difference) (Table 5).

To sum up, it may be established that calcium is to be found in the plant and the bark in nearly identical amounts, though the Ca-content of the bark may be higher. The dynamism of Ca seems to be opposite to that of potassium,

Table 5

Comparative evaluation of the K-, Ca-, P- and N-content (mg/air-dry substance) of samples I/1—V/1 of Hypnum cupressiforme

	Living		Dead		Bark	
	Hypnum I/2	*Hypnum* I/1–V/1	*Hypnum* I/2	*Hypnum* I/1–V/1	*Hypnum* I/2	*Hypnum* I/1–V/1
			K			
$\overline{X}$	4.1	3.66	3.32	3.12	1.16	2.87
$\overline{X}_1-\overline{X}_2$	0.44		0.20		1.71	
t	1.09		0.84		7.91	
$t_{5\%}$	2.44		2.12		2.12	
$SD_{5\%}$	—		—		0.84	
			Ca			
$\overline{X}$	2.73	2.67	3.48	4.42	11.6	9.43
$\overline{X}_1-\overline{X}_2$	0.06		0.94		2.17	
t	0.38		1.19		0.91	
$t_{5\%}$	2.13		2.13		2.13	
$SD_{5\%}$	—		—		—	
			P			
$\overline{X}$	1.99	2.26	1.60	1.96	1.08	0.96
$\overline{X}_1-\overline{X}_2$	0.21		0.36		0.12	
t	5.86		8.78		0.92	
$t_{5\%}$	2.05		2.05		2.17*	
$SD_{5\%}$	0.09		0.08		—	
			N			
$\overline{X}$	10.17	15.04	7.69	7.90	5.58	12.03
$\overline{X}_1-\overline{X}_2$	4.87		0.21		6.45	
t	6.78		0.25		15.21	
$t_{5\%}$	2.01		2.01		2.01	
$SD_{5\%}$	1.44		—		0.87	

because under more balanced conditions calcium occurs rather in the body of the moss, while under more arid conditions it occurs in greater quantities in the bark.

The amount of *phosphorus* is three times as high in the plant as in the bark. Within the plant, the P-content of the living reactions is always higher

(Table 1). A comparison between the P-values of the January xero- and mesotypical samples shows a significantly higher P-content in the mesotypical *Hypnum* samples. The phosphorus content of the bark underneath the moss cushions is approximately identical (Table 2). The comparison between the xerotypical samples of January and the mesotypical samples of May indicates that the samples collected in May have a considerably higher P-content (Table 3), but the P-content of the bark is more significant in the January samples. It is to be seen from the comparison of the mesotypical samples of January and May that their phosphorus contents are nearly identical, a significant difference occurs only in the bark, namely in favour of the samples of January (Table 4). If the P-data of the January xerotypical samples are compared with the contracted P-values of the mesotypical samples of January and May, it becomes obvious that the P-content of the mesotypical *Hypnum* is (significantly) higher, but the bark shows a nearly identical P-content in this case (Table 5).

To sum up, it may be stated that the amount of P is significantly higher in the moss plant than in the bark. Besides, it can be proved that the P-content of mesotypical *Hypnum* is always significantly higher. This means that more balanced conditions may favour the P-uptake of the plant.

The amount of *nitrogen* in the plant is two to three times as high as in the bark. Within the plant the N-content of the living parts always exceeds to some extent the N-content of the dead fraction (Table 1). A comparison between the xero- and mesotypical *Hypnum* cushions showed a — significantly greater — one and a half to two times as high N-content in the mesotypical samples, moreover the bark contained, underneath the latter, a nearly threefold N-content (Table 2). A comparison between the January xerotypical and the mesotypical samples of May led to approximately identical results. The amount of nitrogen was in all cases significantly higher in the mesotypical samples, including the N-content of the bark underneath them (Table 3). The nitrogen content of the mesotypical samples of January and May was roughly identical (Table 4). Thus the higher N-content of the January xerotypical samples and of the mesotypical samples (of January and May) may be regarded as characteristic (Table 5).

To sum up, it may be established that the amount of nitrogen is always higher in the moss plant than in the bark. Moreover, it can be proved that the N-content of the mesotypical samples is nearly always significantly higher than that of the xerotypical samples. This proves beyond doubt that the favourable N-cycle of the epiphytic *Hypnum* is connected with more balanced ecological conditions.

Development of the total *amino acid* content is similar to that of the nitrogen content. It occurs mostly in living moss plants, a less amount is to be found in dead fractions and a very small amount occurs in the bark (Table 6).

Also a comparison between xerotypical and mesotypical samples indicates

Table 6

	I/2	I/1	V/1
Living	3.95	5.38	5.56
Dead	2.20	2.71	3.08
Bark	0.84	0.80	1.33

that the total amino acid content of mesotypical samples is significantly higher both in the living and in the dead fractions. It may be presumed that this phenomenon can be explained by the different metabolism of the two types. This is proved by the investigations of PUSTOVOITOVA (1970) who established that, during the desiccation of mosses, in the xerotypical specimens substances stimulating growing, while in the mesotypical specimens substances prohibiting growing, were accumulated.

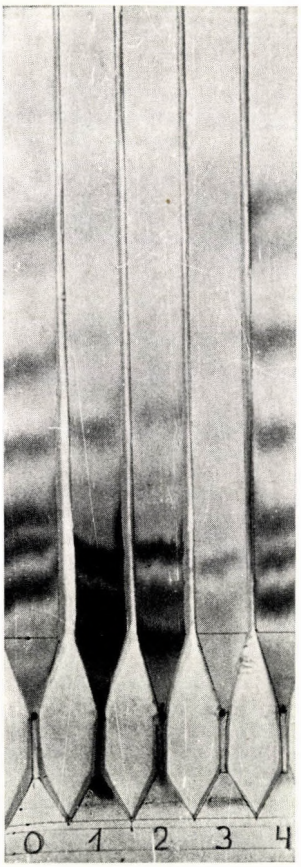


Fig. 1. Paper chromatograph of amino acids. 1 = amino acid standard, 2 = living moss, 3 = dead moss, 4 = bark

The paper chromatographic amino acid investigations of mosses and barks similarly indicate (Fig. 1) that living mosses contain the greatest amounts of amino acids (strip 2), their quantity is less in dead fraction (strip 3), while it is the smallest in the bark (strip 4). Further it can be stated that all three variants contain, first of all, amino acids moving slowly, such as: glycine, serine, asparagine acid, glutamine, arginine, lysine, histidine and cysteine.

Estimation of production. The total K-, Ca-, P-, N- and amino acid contents of the epiphytic *Hypnum*-cushions occurring in the forest stand of 200 sq.m unit area, on the basis of data obtained in January — taking into consideration the total dry weight determined earlier (SIMON 1974) — are presented in Table 7.

Table 7

	mg/200 sq.m				
	Thickness groups				
	1	2	3	Total (mg)	g/ha
K	2205.6	2499.0	1244.1	5 948.7	297.4
Ca	2278.2	2088.2	785.9	5 152.3	257.6
P	1175.2	1209.1	538.8	2 923.2	146.1
N	8508.5	6008.5	1098.2	15 615.2	780.8
Amino acid	2350.9	2071.3	722.4	5 144.6	257.2

This means that on one hectare of the model area the relatively poorly developed epiphytic cover contains exactly 300 g of potassium, 260 g of calcium, 150 g of phosphorus, 780 g of nitrogen and 260 g of amino acid.

Summary

As a part of the epiphytic moss-phytomass investigations carried out by the authors (SIMON 1974) in the area of the "Síkfőkút Project", the K-, Ca-, P-, N- and amino acid content of *Hypnum cupressiforme* has now also been studied.

The authors determined the amount of these elements in the living and dead fractions of the moss and in the substrate bark (Tables 1 and 6). The obtained data were evaluated by the mathematical-statistical method and the differences controlled by the help of the "t-test" (Tables 2, 3, 4, 5). The authors established that K is first of all to be found in the plant, but its amount varies according to the character of the micro-habitat. Under dry conditions there is more K in the plant, under more balanced (more humid) conditions it may move into the bark. Generally there is a greater amount of Ca in the

plant, or the Ca-contents of the moss and the bark are nearly identical. Dead moss fractions contain more Ca than living ones. The dynamism of Ca seems to be opposite to that of K. The amount of P is about three times as much in the plant as in the bark and phosphorus occurs in greater quantities in the living than in the dead fraction. Its amount in *Hypnum* growing under more humid conditions is always significantly higher that in those growing under drier conditions. N-content is higher in the plant than in the bark; within the plant the living fractions contain more N than the dead fractions. The nitrogen content of *Hypnum* growing in more humid micro-habitats is significantly higher. The development of the amino acid content (Table 6) is similar to that of the N-content. Among the amino acids, glycine, serine, asparagine acid, glutamine, arginine, lysine, histidine and cysteine were traceable (Fig. 1). Taking into consideration and converting the dry-weight of epiphytic *Hypnum*-cushions falling to the unit area of 200 sq.m, the estimated values for one hectare are as follows: about 300 g of potassium, 260 g of calcium, 150 g of phosphorus, 780 g of nitrogen and 260 g of amino acids.

REFERENCES

Barkman, J. J. (1958): Phytosociology and Ecology of Cryptogamic Epiphytes. Assen, Netherlands.

Bendz, G.—Svensson, L. (1971): Volatile compounds from Fontinalis antipyretica. Phytochemistry **10,** 3283—3285.

Brehm, K. (1971): Ein Sphagnum-Bult als Beispiel einer natürlichen Ionenaustauschersäule. (A hummock of Sphagnum: An example of a natural ion-exchanging column.) Beitr. Biol. Pflanzen **47,** 287—312.

Erametsa, O.—Yliruokanen, I. (1971): Niobium, molybdenum, hafnium, tungsten, thorium and uranium in lichens and mosses. Suom. Kem. B. **44,** 372—374.

Huneck, S. (1969): Recent literature on the Chemistry of Liverworts and Mosses. Misc. Bryol. et Lichenol. **5,** 49—51.

Huneck, S. (1972): Neue Ergebnisse zur Chemie der Moose, eine Übersicht. Teil 3. Journ. Hatt. Bot. Lab. **36,** 1—11.

Jakucs, P. (1973): "Síkfőkút Project." Egy tölgyes ökoszisztéma környezetbiológiai kutatása a bioszféra program keretén belül ("Síkfőkút Project." Environmental-biological research of an oak forest ecosystem within the framework of the biosphere programme). MTA Biol. Oszt. Közl. **16,** 11—25.

Lewis, D. H. (1971): Chemotaxonomic aspects of the distribution of acyclic sugar alcohols in leafy liverworts: I. Chemical evidence for the taxonomic position of Plagiochila carringtonii (Balfour) Grolle. Trans. Br. Bryol. Soc. **6,** 108—113.

Matsuo, A.—Mitsuru, N.—Shuichi, H. (1972): Aromatic esters from the liverworts, Isotachis japonica. Z. Naturforsch. T. B. **26,** 1023—1025.

Pálfi, G. (1970): A kultúrnövények szabad aminosav összetételének alakulása vízhiány és fiziológiai szárazság hatására (Effects of water deficiency and physiological dryness on the formation of the composition of free amino acids in cultivated plants). Doktori értekezés, p. 450 (MTA Könyvtára, Budapest).

Пустовойтова, Г. Н. (1970): Действие обезвоживания на изменение пригодных, ростовых веществ в тканях листостебельного мха. Физиол. раст. 17, 575—579.

Simon, T. (1974) Estimation of phytomass dry-weight of epiphytic mosses at Síkfőkút (near Eger, N Hungary). Acta Bot. Acad. Sci. Hung. **20,** 341—348.

Smith, G. M. (1955): Cryptogamic Botany. 2. Bryophytes and Pteridophytes. New York, Toronto, London.

SVÁB, J. (1973): Biometriai módszerek a kutatásban (Biometric methods in research). Budapest.
SUIRE, C. (1975): Les données actuelles sur la chimie des Bryophytes. Rev. Bryol. et Lichen. **41,** 105—256.
SZABÓ, M. (1976): Nutrient content of throughfall and stemflow water in an oak-forest (Quercetum petraeae-cerris) ecosystem. Acta Agronom. Hung. (in press).
TAMM, C. O. (1954): Growth, yield and nutrition in carpets of a forest moss Hylocomium splendens. Reports of the forest research institute of Sweden. **43,** 12—38.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1—2), pp. 29—38 (1976)

CHLOROPHYLL CONCENTRATION AND ITS ECOLOGICAL SIGNIFICANCE IN SOME SPECIES IN BEECHWOODS

By

R. M. DRASKOVITS and G. FEKETE

DEPARTMENT OF PLANT TAXONOMY AND ECOLOGY, EÖTVÖS L. UNIVERSITY, BUDAPEST

AND BOTANICAL DEPARTMENT, HUNGARIAN NATURAL HISTORY MUSEUM, BUDAPEST

(Received January 7, 1976)

The chlorophyll-a and -b as well as the pigment ratio in herb layer species dominant in beechwoods *(Asperula odorata, Dentaria bulbifera, Melica uniflora, Viola alba, Carex pilosa)* were examined in 3 beech stands of various ages and structures. All five species are remarkable owing to their low total chlorophyll density. It is attributable to the light climate created by the structure of the tree stand that the total chlorophyll density of the two species, viz. *Dentaria bulbifera* and *Asperula odorata*, is different according to the age groups. The chlorophyll level of the other three species was not effected by the light climate of the stand. The decreasing trends of the a/b ratios are not attributable to the decrease in the average illumination values. In *Carex pilosa* and *Viola alba* individuals, overwintering leaves also function. These are of low a/b ratio and of a higher total chlorophyll density in character as compared with the fresh leaves.

Introduction

By a quantitative analysis of the photosynthetic pigments, useful information is obtainable in a number of situation on the photosynthetic production and capacity of plants as well as on their light ecological sensitivity and tolerance. In forest herb layer plants, as also in our case questions arise whether the stand structure of the forest, and the various light ecological effects related to it, have any influence on the total pigment density and on the density or ratios of the various components. It may well be of interest to know whether the species occurring at the same vegetation level show similar or deviating ecological reactions in relation to the above properties.

Material and methods

In the spring of 1974 we collected frequently occurring beechwood plant species for chlorophyll sampling in the extrazonal beeches of the Pilis Mountain (Central Hungary) in the range of the Vöröskő rock at the village of Tahi, latitude 47°46', 350 m a.s.l. The species with the indication of their life form were as follows: *Asperula odorata* H, *Dentaria bulbifera* G, *Melica uniflora* H, *Carex pilosa* H, *Viola alba* H. The species enumerated here were collected according to age group per beech stand (in 3 age groups; cf. M. DRASKOVITS, 1975), and in 3 repetitions by age groups. For the sampling times see Table 2.

Discs of known surface area were cut out of the leaves. At the time of sampling, care was taken that the discs were always cut from the same section of the same leaf of the plant individual (for example, one disc from each of the 6 leaves of the third whorl from above in *Asperula*). The chlorophyll components were brought into solution by means of cc. acetone

(with the addition of a small quantity of $MgCO_3$); they were filtered through a glass-strainer, then photometered (on a Spektromom photometer, at E 663 and 645 nm wave lengths; cf. ARNON, 1949).

The differences in chlorophyll concentration according to stand ages were evaluated by means of random-arranged analysis of variance (SVÁB, 1973).

The results were also related to the photometric data obtained in 1974, when the investigations were carried out in the same stand age groups (M. DRASKOVITS, 1975). These stands differ from one another in trunk height, diameter, density — in one word, in the light climate effecting the herb layer. The major illumination averages of the measurement days (each of them is an average of 2—3000 measurements) are given in Table 1 for orientation.

Table 1

The daily average values of the illumination measurements, in Klux

Date / Age	3 Apr.	12 Apr.	23 Apr.	15 May	20 Je.	23 Jul.	17 Sept.	20 Nov.
1. Young	6.65	1.93	1.34	0.41	0.38	0.41	0.50	6.44
2. Middle-aged	6.30	2.61	2.30	0.43		0.38	0.26	4.85
3. Old	6.24	1.67	1.23	0.43	0.36	0.40	0.22	4.40

Table 2

The chlorophyll content

		Dentaria bulbifera 24. 3. 1974.			*Asperula odorata* 25. 4. 1974.			*Melica uniflora* 21. 5. 1974.		
		1.	2.	3.	1.	2.	3.	1.	2.	3.
A	chl a mg/100 cm²	1.34	1.34	1.34	0.68	0.64	0.65	0.88	0.98	1.29
	chl b mg/100 cm²	0.62	0.56	0.57	0.30	0.30	0.30	0.42	0.44	0.65
	chl a+b mg/100 cm²	1.96	1.90	1.91	0.98	0.94	0.95	1.30	1.42	1.94
	chl a/b	2.17	2.41	2.36	2.22	2.12	2.19	2.10	2.23	1.98
	leaf weight g/100 cm²	0.71	0.78	0.74	0.81	0.79	0.77	0.41	0.40	0.40
B	chl a mg/100 cm²	1.09	1.11	1.10	0.85	0.84	0.90	1.19	1.03	0.80
	chl b mg/100 cm²	0.48	0.45	0.47	0.37	0.38	0.39	0.55	0.49	0.43
	chl a+b mg/100 cm²	1.57	1.56	1.57	1.22	1.22	1.29	1.74	1.52	1.32
	chl a/b	2.28	2.45	2.35	2.28	2.20	2.31	2.17	2.11	2.03
	leaf weight g/100 cm²	1.03	0.86	0.95	0.76	0.87	0.90	0.37	0.38	0.35
C	chl a mg/100 cm²	1.09	1.10	1.10	1.32	0.95	0.74	0.95	1.08	0.88
	chl b mg/100 cm²	0.40	0.44	0.41	0.60	0.39	0.37	0.43	0.57	1.44
	chl a+b mg/100 cm²	1.49	1.54	1.51	1.92	1.34	1.09	1.38	1.65	1.32
	chl a/b	2.74	2.51	2.63	2.19	2.39	1.95	2.17	1.86	2.01
	leaf weight g/100 cm²	0.72	0.80	0.75	0.87	0.80	0.85	0.36	0.33	0.43

1. 2. 3. = Repetitions

A B C = Beechwoods of different ages: A, young stand; B, middle-aged stand; C, old, mature stand

Results

The data given in Table 2 will be the basis of discussion on the possible adaptations according to stand ages.

Figure 1 shows the result of examining the chlorophyll density of the various species on the basis of the data given above, independently of the three stands. This provides information on the amplitude per species of the chlorophyll concentration.

Similarly to these said above, the chlorophyll a/b ratio is demonstrated in Fig. 2.

The discussion of the results will be given per species.

Asperula odorata

Chlorophyll concentration rises in the middle-aged stand. The rise ensues in both components.

of the species examined

Viola alba 13. 4. 1974.						*Carex pilosa* 22. 4. 1974.					
fresh leaf			overwintering 1.			fresh leaf			overwintering 1.		
1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
1.13	0.91	0.74	1.23	1.38	0.98	0.93	0.77	0.45	2.20	1.36	1.00
0.57	0.40	0.32	1.08	0.62	0.93	0.97	0.33	0.17	1.02	0.86	0.41
1.70	1.31	1.06	2.31	2.00	1.91	1.30	1.10	0.62	3.22	2.22	1.41
2.00	2.24	2.30	1.13	2.20	1.05	2.53	2.28	2.60	2.14	1.58	2.45
0.76	0.75	0.73	0.66	0.57	0.82	0.66	0.78	0.62	0.99	0.86	0.74
0.82	1.17	1.25	1.11	1.44	1.24	0.93	0.84	0.72	1.66	2.49	1.55
0.43	0.47	0.57	0.98	1.14	1.04	0.58	0.46	0.35	0.86	1.22	0.76
1.25	1.64	1.82	2.09	2.58	2.28	1.51	1.30	1.07	2.52	3.71	2.31
1.91	2.45	2.21	1.13	1.26	1.20	1.60	1.83	2.05	1.92	2.04	2.02
0.78	0.84	0.87	0.77	0.75	0.67	0.64	0.61	0.66	0.86	0.86	0.84
1.33	1.62	1.01	1.61	1.63	1.25	0.96	0.92	0.85	2.25	1.79	2.27
0.50	0.60	0.45	1.01	0.78	1.04	0.45	0.43	0.38	1.06	0.81	1.19
1.83	2.22	1.46	2.62	2.41	2.29	1.41	1.35	1.23	3.31	2.60	3.46
2.64	2.70	2.21	1.60	2.10	1.19	2.14	2.15	2.21	2.12	2.19	1.90
0.98	0.87	0.93	0.95	0.82	0.92	0.71	0.61	0.59	1.03	0.83	1.11

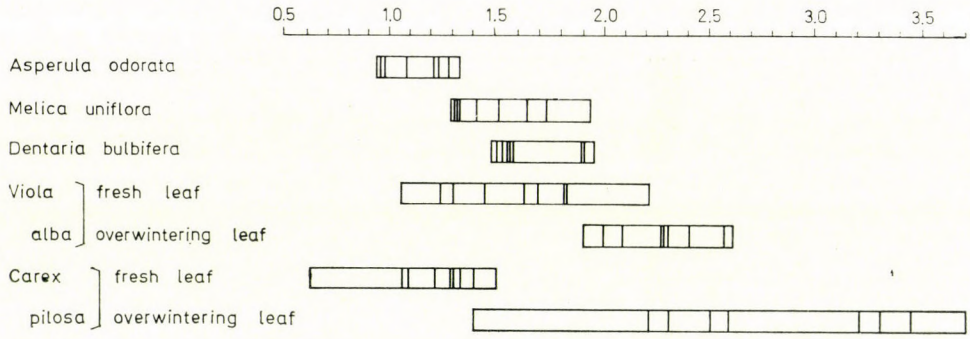


Fig. 1. The variability — on the basis of all data — of the chlorophyll content in the species examined (mg chl a + b/100 cm²)

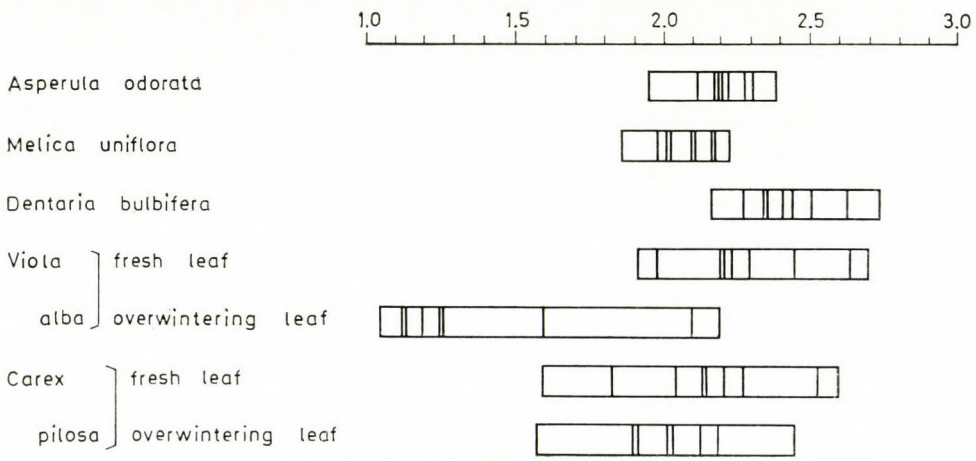


Fig. 2. The variability — on the basis of all data — of the chlorophyll a/b ratio in the species examined

After subjecting the data of the 3 stands to a statistical analysis, it appeared that, owing to the great variability of the data of plants living in the old stand, the result (the effect of the stand "treatments") is not significant (NS). When the comparison refers to only two age groups, that is, to the young and middle-aged stands, the chlorophyll concentration of *Asperula* is significantly different in the two stands.

It cannot be stated with certainty to what cause the unambiguous rise in the chlorophyll level of the middle-aged stand, best illuminated in April (cf. Table 1), is ascribable. One might assume that the pigment level moves around the minimum, and in the middle-aged stand (which is illuminated better by mid April) the concentration increases parallel with illumination

(on the stimulation of illumination). This explanation seems to be confirmed by the fact of anatomical adaptation: in the young stand it is the sciophyll leaves of *Asperula* which develop (low ratio of weight)surface and low density thickness; sensu McCLENDON, 1962).

Table 3

Variance analysis of the data

Source of variability	SQ	FG	MQ
Total	0.1279	5	
Treatment	0.1241	1	0.1241***
Error	0.0037	4	0.00093

*** P = 0.1%

All these, however, are contradicted by the fact in the individuals growing in the old stand with similarly weak illumination, chlorophyll density rises likewise, though unevenly. It is therefore a likelier explanation that in the middle-aged (and old) stands the effect of the illumination, which was decreasing in the preceding summer vegetation period, manifests itself in this long-function in species. With regard to both chlorophyll-a and chlorophyll-b the three repetitions in the old stand are strongly fluctuating, possibly because of the coarse-grained pattern of strong light and shadow produced by the thick beach trunks. In the young and middle-aged stands with fine grained light and shadow pattern the fluctuation of the chlorophyll concentrations is of a lower degree.

Dentaria bulbifera

The role of the stand structure is of a different trend in the early spring-time geophyton *Dentaria* than in the hemicryptophyton *Asperula*. While in *Asperula* the total chlorophyll level is lowest in the young stand and this increases with the age of the forest, in *Dentaria* it is highest in the young stand and decreases with the age of the forest.

The result of the 3-treatment analysis of variance is significant (Table 4). In a comparison by pairs, the deviation of the total chlorophyll level in *Asperula* individuals living in the young stand from those two which are similar to each other is demonstrable.

The chlorophyll-a/b ratio in the old stand increased considerably, which follows from the decrease in component b. It is not known whether the quantity of cholophyll-b decreases as a result of light fluctuating very strongly. For in

Table 4

Variance analysis of the data and the comparison by pairs of the averages of the three stands

Source of variability	SQ	FG	MQ
Total	0.2977	8	
Treatment	0.2947	2	0.14734***
Error	0.0030	6	0.00051

*** P = 0.1%

	1	2	3
1	1.926	X	X
2	0.356	1.570	
3	0.407	0.051	1.519

XP=5%

the early-spring time in the still leafless, old stand, the trunks standing far from each other bring into existence coarse grained light and shadow patterns. Thus the plant individual, growing at a given point of the herb layer is alternatively under the effects of now strong illumination the deep shadow, for rather protracted periods.

The adaptation ensuing in the photosynthetic pigment levels is not parallel with the anatomical adaptation; the weight/surface ratio is lower in the young and in the old stands, while it is higher in the middle-aged stand. These values are adequate to the illumination values measured in fully-grown plants.

Melica uniflora

In the change of the total chlorophyll concentration in *Melica*, no trend per age group (light–climate) manifests itself. Variability is high in all three age groups, the result of the variance analysis is NS.

With respect to the chlorophyll concentration (the components separately and in total; cf. Table 2), *Melica*, *Asperula* and *Dentaria* are closely related. Their similarity is underlined by the fact that, considering all measurements taken in the stands with different illuminations, the pigment concentration and their ratio in all three species are rather fixed values (narrow interval; Figs 1 and 2).

The concentration and ratio in the chlorophyll components is, however, much more evenly distributed among the extreme values in *Melica* than in the

other two species. Similarly near the same is the weight/surface ratio in the samples of *Melica* leaves originating from the different beechwood stands; however, in comparison with the *Asperula* and *Dentaria* values, this value is only half as much as theirs. Thus, in the half as thick sciophyl leaf *Melica*, the pigment concentration is twice as much as that in the other two species.

Viola alba

Owing to the circumstance that there are two kinds of leaves, *viz.* fresh and overwintering leaves, in *Viola alba* and *Carex pilosa* (see below), they raise problems in other directions as well.

Young, fresh leaves and overwintering leaves were treated separately. The concentration of chlorophyll in the young, fresh leaf increases with the age of the forest. Although this statement is valid for the average, the differences are not significant because the variability of the 3 repetitions within one stand is great. The factors examined constitute a series of gradual transition. The average of the chlorophyll a/b ratio is the only one which rises both in the fresh leaves and in the overwintering ones in the old stand, which is mainly attributable to the accumulation of the chlorophyll-a component. Presumably, the effect of light and shadow fluctuation also appears in this species (cf. *Dentaria*). The chlorophyll data of the fresh leaf samples taken in the young and in the middle-aged forest stands are very similar; in the overwintering leaves, the values originating from the middle-aged and from the old forest stands are closely related. In view of the fact that the overwintering leaf manifests the conditions of the preceding year, the statement made above coincide with the fact known from our illumination measurements, namely that in a great portion of the vegetation period, the conditions of illumination are similar in the middle-aged and in the old stands; the light climates of the two forest stands are closely related during this period.

Carex pilosa

With respect to chlorophyll density and ratio, *Carex pilosa* — similarly to *Viola alba* — shows of a wide interval concerning both the fresh and the overwintering leaves (see Fig. 2). It appears that among the species examined *Carex pilosa* has the widest light ecology. Within the given beech forest type, it is the least sensitive to the ecological effects following from the differences in age of the various stands. However, the difference between the fresh and overwintering leaves is remarkable. In *Carex pilosa*, the total chlorophyll concentration of the overwintering leaves is 2—2.5 times that of the fresh leaves. Not only the chlorophyll-b component increases, but in all of the cases the chlorophyll-a component also does so, to a considerable extent. The a/b

ratio is also lower in the overwintering leaves, similarly as in *Viola*, but the drop is less expressed. In the overwintering leaves the weight/surface ratio slightly increases (not so in *Viola*), which is probably a consequence of the continuous sclerenchyma formation.

Discussion

One of the indications of the photosynthetic capacity in species — especially in the domain of low light intensity — is the density of photosynthetic pigments. The unexpectedly low pigment concentration of herb layer plants in beechwoods is remarkable in comparison with other data published in the literature. This can be established even if one is aware of the fact that in the comparison the different thickness of the leaves is always disturbing. The upper limit values measured in the various species still express only rather low pigment concentrations (Fig. 1). Concerning "obligatory shade plants", LUNDEGÅRDH (1954) had already called attention to the narrow amplitude of the values.

The examples of comparison (taken randomly from the extensive literature) refer partly to culture plants and partly to elements of natural vegetation (chlorophyll a + b, mg/related to 100 cm^2 leaf area).

Trifolium repens: 3.4—5.3; *Lolium italicum:* 1.5—6.0 (OKUBO—OIZUMI—HOSHINO—NISHIMURA, 1968); *Phaseolus vulgaris:* 0.5—4.5 (TSUJA—ISA—HATEKYAMA, 1970); *Medicago sativa:* 3.2—5.1 (OKUBO—KAWANABE—HOSHINO, 1971); *Nicotiana sanderae:* 2.0—4.5 (ŠESTÁK—ČATSKÝ, 1962); *Secale cereale:* 1.1—3.2 (ORBÁN, 1972); *Brassica oleracea* var. *acephala:* 1—5 (ŠESTÁK, 1963); *Zea mays:* 1—4 (ŠESTÁK—VÁCLAVIK, 1963). The level is also higher in trees: *Populus tremuloides:* 3.6—4.9 (light-leaves), 2.6—3.8 (shade-leaves; PEARSON—LAWRENCE, 1958); *Quercus petraea:* 1.4—3.2 (light-leaves), 1.3—3.0 (shade-leaves; FEKETE—SZUJKÓ-LACZA mscr.); *Quercus pubescens:* 2.2—2.5 (FEKETE—SZUJKÓ-LACZA mscr.). With *Rhododendron maximum:* 2.2—5.5 (WHITTAKER—GARFINE, 1962). In mixed samples of open sand grassland (*Festucetum vaginatae* danubiale), the weighted average of the components — characteristic of the vegetation — is 2.0—5.2 (ORBÁN, 1972). — According to GABRIELSEN (1948) 5 mg is to be regarded as the optimum level.

In the three experimental beech stands (in the 3 age groups), the fact that the chlorophyll density is controlled by some enviromnental factor (stand structure) could be established in two of the five abundant species of the herb layer. The total chlorophyll concentration of *Asperula odorata* is higher — confirmed also statistically — in the middle-aged stand, while that of *Dentaria bulbifera* is higher in the young stand. However, the comparison of these results with the data of light measurements made parallel with the

above experiments suggests that it is not simply the illumination gradient dominant at the time of the chlorophyll sampling that determines the formation of the chlorophyll level, but also, for example, the light conditions of the preceeding period, be it that of year's vegetation.

The light ecological importance of the chlorophyll-a/b ratio is without doubt. Chlorophyll-b is known as "shade-chlorophyll". Its accumulation in the lower, shaded layers of the vegetation is useful, because by its capacity for absorbing light energy of a shorter wave length it transfers energy to chlorophyll-a which can absorb it only of a longer wave length, and which performs the chemical part of the photochemical action (energy concentration). On the basis of the works by BOARDMAN—ANDERSON (1964), GROSS—SHEFNER—BECKER (1966) etc. it is also known that chlorophyll-a-b are present in both of the photochemical systems; System I is characterized by about twice as high a/b ratio as is characteristic of System II. However, the decreasing trends in the a/b ratio of the beechwood species herein examined cannot be explained by the decrease of the average illumination values. The extent up to which the rate of fluctuation in the illumination is responsible for the tendencies mentioned above is not known. Under natural conditions, the fluctuation of illumination is also invariably superimposed on the changes in the average illumination intensities; it is impossible to study these two causes separately here.

In investigations conducted under natural conditions, the question of leaf age groups (fresh leaves, or overwintering leaves of the preceding year) also arises. The low a/b ratio evolves in the overwintering leaves rather peculiarly. In both *Carex pilosa* and *Viola alba* the chlorophyll-b component increases to about its twofold, in comparison with that of the fresh leaves. At the same time, the chlorophyll-a concentration also increases but not to an identical extent. (The increase in the concentration of the two components in the overwintering leaves of *Viola alba* and *Carex pilosa* results, in their pigment density being already nearer to that occurring in the species taken for comparison.) These trends are independent of the age group of the tree stand. The increase in pigment density, independent of external effects (the role of stand structure), could be considered a kind of adaptation induced by internal causes ("shading" by the epidermis or cuticle; RABINOVITCH, 1955). However, the supposed change in internal structure manifests itself in the weight/surface ratios — according to the comparison with the fresh leaves — only in one of the species, *i.e.*: in *Carex pilosa*.

REFERENCES

ARNON, D. I. (1949): Copper enzymes in isolated chloroplasts. Polyphenoloxidase in Beta vulgaris. Plant Physiol. **24,** 1—15.

BOARDMAN, N. K.—ANDERSON, J. M. (1964): Isolation from spinach chloroplasts of particles containing different proportions of chlorophyll-a and -b and their possible role in the light reactions of photosynthesis. Nature, **203,** 166—167.

DRASKOVITS, R. M. (1975): Light intensity studies in beechwoods of different ages. Acta Bot. Acad. Sci. Hung. **21,** 9—23.

GABRIELSEN, E. K. (1948): Effect of different chlorophyll concentrations on photosynthesis in foliage leaves. Physiol. Plant. **1,** 5—37.

GROSS, J. A.—SHEFNER, A. M.—BECKER, M. J. (1966): Distribution of chlorophylls in chloroplast fragments. Nature **209,** 615.

LUNDEGÅRDH, H. (1954): Klima und Boden in ihrer Wirkung auf das Pflanzenleben. Vierte Auflage. Gustav Fischer, Jena, pp. 598.

MCCLENDON, J. (1962): The relationship between the thickness of deciduous leaves and their maximum photosynthetic rate. Amer. J. of Botany **49,** 320—322.

OKUBO, T.—KAWANABE, S.—HOSHINO, M. (1971): Seasonal variation of maximal crop growth rate and energy efficiency and their correlation with chlorophyll content of leaves. JIBP/PP, level III. experiments, 24—29.

OKUBO, T.—OIZUMI, H.—HOSHINO, M.—NISHIMURA, S. (1968): Changes in chlorophyll index and LAI with regrowth in a forage crop community. JIBP/PP, level III. experiments, 43—46.

ORBÁN, S. (1972): Seasonal changes of assimilating surface and chlorophyll content in Festucetum vaginatae and Secaletum cultum communities. Acta Agr. Acad. Sci. Hung. **21,** 418—428.

PEARSON, L. C.—LAWRENCE, D. B. (1958): Photosynthesis in aspen bark. Amer. J. of Botany **45,** 383—387.

RABINOVITCH, E. I. (1955): Photosynthesis and related processes. Vol. II. Part III. Intersci. Publ., New York.

ŠESTÁK, Z. (1966): Limitations for finding a linear relationship between chlorophyll content and photosynthetic activity. Biol. Plant. (Praha) **8,** 336—346.

ŠESTÁK, Z.—ČATSKÝ, J. (1962): Intensity of photosynthesis and chlorophyll content as related to leaf age in Nicotiana sanderae hort. Biol. Plant. (Praha) **4,** 131—140.

ŠESTÁK, Z.—VÁCLAVIK, J. (1963): Relationship between chlorophyll content and photosynthetic rate during the vegetation season in maize grown at different constant soil water levels. In: Water stress in plants (Symposium, Prague, 1963), 210—218.

SVÁB, J. (1973): Biometriai módszerek a kutatásban (Biometrical methods in research) II, Mezőgazdasági Kiadó, Budapest. pp. 517.

TSUJA, H.—ISA, Y.—HATEKYAMA, I. (1970): Changes in characteristics of photosynthesis-light curve and chlorophyll contents of growing bean leaves. JIBP/PP, level III. experiments, 64—67.

WHITTAKER, R. H.—GARFINE, V. (1962): Leaf characteristics and chlorophyll in relation to exposure and production in Rhododendron maximum. Ecology **43,** 120—125.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1–2), pp. 39–49 (1976)

ORGANIC MATTER PRODUCTION AND PHOTOSYNTHETIC ENERGY UTILIZATION OF A PLANT ASSOCIATION IN LOESS GRASSLAND

By

L. ENDRÉDI and I. HORVÁTH

BOTANICAL DEPARTMENT, JÓZSEF ATTILA UNIVERSITY, SZEGED AND MAGYAR LÁSZLÓ SECONDARY SCHOOL, DUNAFÖLDVÁR

(Received March 2, 1976)

The organic matter production and the energy utilization of the plant association *Salvio-Festucetum rupicolae pannonicum stipetosum capillatae* of the Mezőföld area were examined from the end of April, 1974 to the end of October of the same year. The weight increase reached its highest value in May and June during which time the energy utilization was 0.79% and 1.03%, respectively. Considering the whole of the examination period, the above-ground dry matter production was 281.94 g/m², while productivity was 1.55 g/m²/day, which means a 0.17% average energy utilization. In the dry matter content carbohydrate amounts to 34.5% and nitrogen to 2.1%. A close linear regressional connection exists between the quantity of dry matter and carbohydrate and nitrogen production, while it is looser between the carbohydrate and nitrogen productions.

Introduction

The production-biological examinations conducted at the Botanical Department of the József Attila University (BODROGKÖZY—HORVÁTH, 1969; HORVÁTH, 1972), were extended to an investigation of the organic matter production and photosynthetic energy utilization of a loessgrassland (*Salvio-Festucetum rupicolae pannonicum* Zólyomi, 58). Of the results of examinations being carried out, the above-ground organic matter production and energy utilization of one of the stands will be discussed (Fig. 1).

Material and method

The area of examination is the western slope of the Nagyhegy at Dunaföldvár where the ancient loess vegetation (BOROS, 1958; 1959; ZÓLYOMI, 1958a, b; 1967), characteristic of the loess areas of the Mezőföld (ÁDÁM et al., 1959; MAROSI—SZILÁRD, 1967), has survived practically undisturbed by anthropogenic effects. Our samples have been obtained from the *stipetosum capillatae* Soó 59 (Soó, 1964; 1973) stand of the association *Salvio-Festucetum rupicolae pannonicum* Zólyomi 58, covering the upper two-thirds of the hillside. The investigations were carried out on 7 occasions from the end of April to the end of October, 1974.

Of the above-ground plant parts samples were taken monthly, by mowing (ODUM 1959), with random selection, from four areas of 25 × 25 cm each. In the further calculations the average of the four replications was used. The mowed plants were separated into living parts and litter, while the living parts into *Stipa*, *Festuca*, *Salvia* and other species. The samples were dried at 80°C up until no change in weight showed, and the dry weight was calculated for 1 m² area. The total carbohydrate and nitrogen contents were determined and related also to a unit area (1 m²).

Examination dates	Days passing between two samplings
29 April	
30 May	31
27 June	28
30 July	33
30 August	31
28 September	29
28 October	30

Total period of examination: 182 days

The determination of the total carbohydrate content was carried out with the phenol-sulphuric method of DUBOIS et al. (1956) after a two hours' hydrolization on hot water bath, with 2% hydrochloric acid. The determination of the total nitrogen content was made according to KELLEY et al. (1946), after destruction with concentrated sulphur. Photometry was carried out with a Spekol-type spectrophotometer at 495 and 420 nm, respectively. The calibrational straight was determined with glycose and ammonium chloride, respectively.

Among the climatic factors, air temperature, moisture quantity, duration of sunshine and global radiation were considered (see Table 1). The measuring of temperature and moisture quantity was carried out in the field, while the data of the duration of sunshine and of global radiation were obtained from the measurements of the Agrometeorological Observatory Institute (Martonvásár) of the HAS. (For the availability of the data thanks are due to Dr. János PLETSER, Head of the Observatory).

Table 1

Meteorological data of the period investigated

Period	Temperature °C			Global radiation (cal/cm²)	Sunshine, h	Moisture, mm
	Min.	Max	Mean			
IV. 29—V. 29.	5.5	27.0	18.1	12.939	195.8	88.40
V. 30—VI. 26.	6.0	31.0	17.9	12.385	195.5	38.05
VI. 27—VII. 29.	11.5	35.5	20.5	15.390	214.0	60.60
VII. 30—VIII. 29.	11.0	37.0	23.6	12,420	255.0	84.90
VIII. 30—IX. 27.	4.0	29.5	18.4	8.389	187.3	32.35
IX. 28—X. 27.	0.5	17.0	7.7	3.826	75.3	169.90
IV. 29—X. 27.	0.5	37.0	17.7	65.349	1122.9	474.20

In calculating the energy utilization, 1 g of organic plant matter was considered to equal 4000 cal energy (HAYASHI, 1966). The rate of utilization was calculated according to the following equation (MURATA et al., 1968):

$$\text{Energy conversion } \% = \frac{\text{dry weight (g)} \times 4000 \text{ cal}}{\text{radiated energy (cal)}} \cdot 100$$

This refers to the global radiation, the quantity of which is taken twice for obtaining the photosynthetic energy conversion calculated for PAR.

The correlations between various data characteristic of the organic matter production were examined with regression analysis (SVÁB, 1973).

The dominant species of the stand are *Stipa capillata*, *Festuca rupicola* and *Salvia nemorosa*. Among the other species the following should be mentioned:

Sedum maximum, *Cytisus austriacus*, *Medicago falcata*, *Astragalus onobrychis*, *Falcaria vulgaris*, *Asperula cynanchica*, *Scabiosa ochroleuca*, *Linum tenuifolium*, *Euphorbia cyparassias*, *Nonea pulla*, *Stachys recta*, *Calamintha acinos*, *Thymus marschallianus*, *Verbascum lychnitis*, *Linaria genistifolia*, *Veronica spicata*, *Papaver dubium*, *Campanula sibirica*, *Hypericum perforatum*, *Achillea collina*, *Senecio jakobaea*, *Xeranthemum annuum*, *Centaurea sadleriana*, *Taraxacum serotinum*, *Silene otites*, *Allium sphaerocephalum*, *Allium flavum*, *Asparagus officinalis*, *Poa angustifolia*, *Dactylis glomerata*, *Agropyron repens* (the enumeration follows Soó—Kárpáti, 1968).

The majority of the dry weight of living plant parts was throughout obtained from *Stipa capillata* (its average share was 64%, minimum 41%, maximum 77%). *Festuca rupicola* is rather significant (on the average: 12%, minimum 7%, maximum 33%), and also *Salvia nemorosa* (10% on the average; minimum 0%, maximum 23%).

The average share of the other species was 13% (minimum 6%, maximum 26%).

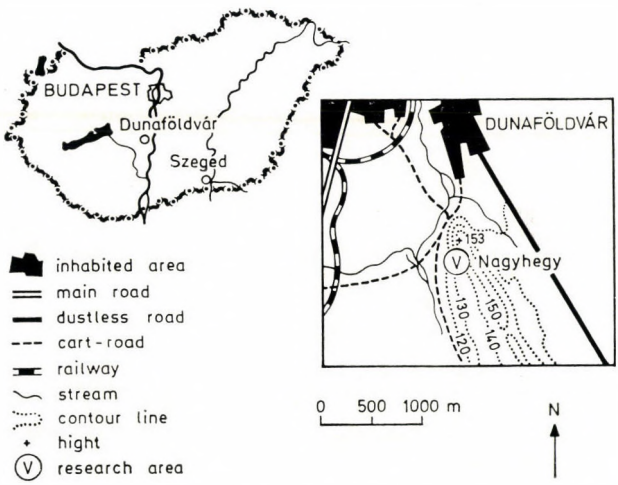


Fig. 1. Nagyhegy and its environment near Dunaföldvár

Results

The cover of the stand varied between 40 and 60% during the vegetation period; it was the greatest in June and July.

The proportion of the dead plant parts was on the average 42% in the dry matter production, part of which originated from the production of the previous years. A great part of the dead matter also consisted of *Stipa capillata* and *Festuca rupicola*.

Changes in the living and dead matter weight proportions of the dominant species during the vegetation period are shown in Fig. 2.

The quantitative data of the organic matter are given in Table 2; the values characteristic of the productivity in the stand are summarized in Table 3, and demonstrated in Fig. 3.

Table 2

Quantitative data of dry matter, total carbohydrate and total nitrogen contents

Time of sampling		Dry weight (g/m²)						
		Living parts					Dead part	Together
		Stipa	*Festuca*	*Salvia*	Other	Total		
IV. 29.	DM	140.10	12.20	8.40	23.08	183.78	201.20	384.98
	CH	29.93	3.71	3.47	5.09	42.20	42.15	83.35
	N	2.38	0.23	0.37	1.04	4.02	4.02	8.04
V. 30.	DM	210.40	45.20	81.20	51.56	388.36	210.12	598.48
	CH	61.48	12.18	11.65	11.14	96.45	43.39	139.84
	N	3.79	0.79	4.87	3.09	12.54	4.83	17.37
VI. 27	DM	360.00	58.40	92.60	66.60	577.60	340.00	917.60
	CH	98.28	16.53	9.45	14.79	139.05	80.92	219.97
	N	10.80	1.23	3.33	4.33	19.69	11.90	31.59
VII. 30.	DM	506.80	70.00	185.60	46.00	808.40	384.00	1192.40
	CH	152.55	21.56	32.48	10.95	217.54	84.67	302.21
	N	14.19	1.64	4.27	2.21	22.31	10.37	32.68
VIII. 30.	DM	362.60	34.40	25.38	66.76	489.14	339.20	828.34
	CH	154.83	8.19	4.44	16.36	183.82	85.48	269.30
	N	8.34	0.62	0.41	1.90	11.27	7.12	18.39
IX. 28.	DM	350.40	40.20	10.40	52.40	453.40	360.20	813.60
	CH	144.71	10.83	1.94	12.47	169.95	93.90	263.85
	N	8.41	0.74	0.15	1.20	10.50	8.46	18.96
X. 28.	DM	72.80	58.32	—	46.60	177.72	489.20	662.92
	CH	29.30	21.64	—	9.76	60.70	119.85	180.55
	N	1.67	0.96	—	1.35	3.98	10.03	14.01

DM = dry matter
CH = carbohydrate, total
N = nitrogen, total

It can be stated that the stand increased up till the end of July, then the quantity of the above-ground dry matter began to decrease, first at a rapid pace then at a slower one. The total production in the period examined was 281.94 g/m², which in a daily average amounts to 1.549 g/m².

Changes in the carbohydrate production follow only partly the course of the dry matter production. The cause of the deviations was that the total carbohydrate concentration significantly changed during the growth period;

Table 3

Productivity of the stand

Period	Dry matter		Total carbohydrate		Total nitrogen	
	Total (g/m^2)	Daily (g/m^2/day)	Total (g/m^2)	Daily (g/m^2/day)	Total (g/m^2)	Daily (g/m^2/day)
IV. 29—V. 29.	+213.50	+ 6.887	+56.49	+1.822	+ 9.33	+0.301
V. 30—VI. 26.	+319.12	+11.397	+80.13	+2.862	+14.22	+0.508
VI. 27—VII. 29.	+274.80	+ 8.327	+82.24	+2.492	+ 1.09	+0.033
VII. 30—VIII. 29.	−364.06	−11.743	−32.91	−1.062	−14.29	−0.461
VIII. 30—IX. 27.	− 14.74	− 0.508	− 5.45	−0.188	+ 0.57	+0.020
IX. 28—X. 27.	−146.68	− 4.889	−83.30	−2.777	− 4.95	−0.165
Total	+281.94	+ 1.549	+97.20	+0.534	+ 5.97	+0.033

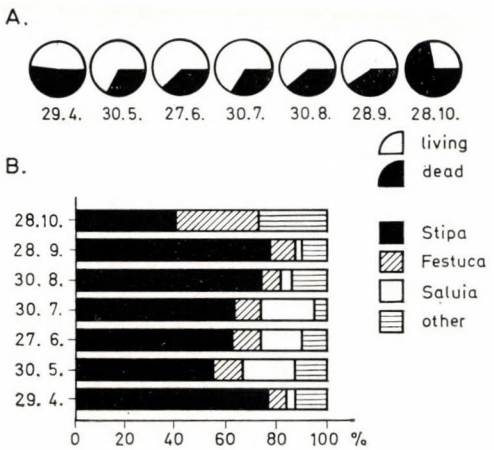


Fig. 2. A: proportion of living and dead plant parts (weight %); B: distribution of living plant parts according to species (weight %)

it reached its maximum in August and it was higher in the second half of the vegetation period.

The carbohydrate production during the vegetation period was 97.20 g/m^2, the daily increase was 0.534 g/m^2. This amounted to 34% of the dry matter production. The changes in the nitrogen production show also only approximately a similar course to those occurring in the dry matter production. The total nitrogen concentration increased up till the end of June, then it decreased and became higher only in the first half of vegetation period (Fig. 4). During the 182 days of the investigation, the total nitrogen production was 5.97g; this corresponds to a daily 0.033 g/m^2 average increase. About 2% of the accumulated dry matter content is nitrogen.

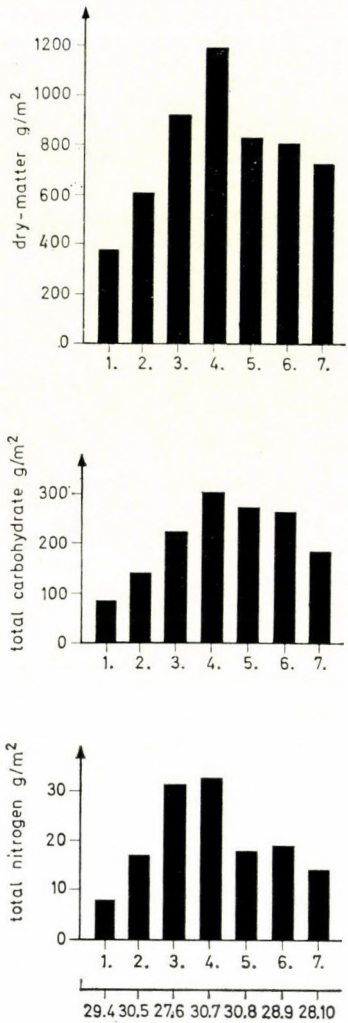


Fig. 3. Changes in the organic matter quantity (dry matter, carbohydrate and nitrogen) in the sampling periods

Discussion

The results of the regression analysis related to the organic matter quantity of a unit area are summarized in Table 4.

On the basis of our data there is a positive correlation between the quantities of dry matter and carbohydrate and nitrogen; their correlation is linear; the total nitrogen content is in a rather close linear regressional correlation with the quantity of the dry matter. However, in the dead plant parts a similarly close correlation can only be found in the total carbohydrate.

Table 4

Results of the dry matter quantity, to the total nitrogen content and to the total carbohydrate content

	Dry matter and carbohydrate production	Dry matter and nitrogen production	Carbohydrate and nitrogen production
Regressional equation ($Y' = a + bX$)			
— in living parts	$Y'=10.81+0.27X$	$Y'=-1.28+0.03X$	$Y'=1.37+0.082X$
— in dead parts	$Y'=11.45+0.27X$	$Y'=+0.47+0.023X$	$Y'=1.86+0.079X$
Regressional coefficient with standard deviation ($b \pm s_b$)			
— in living parts	$+0.27 \pm 0.0545$	$+0.03 \pm 0.0042$	$+0.082 \pm 0.0306$
— in dead parts	$+0.27 \pm 0.0320$	$+0.023 \pm 0.0081$	$+0.079 \pm 0.0315$
Correlation coefficient (r)			
— in living parts	+0.91	+0.95	+0.77
— in dead parts	+0.98	+0.78	+0.75
Determination coefficient (r^2)			
— in living parts	0.8295	0.9118	0.5918
— in dead parts	0.9663	0.6168	0.5599
Probability level of significance in the correlation (P)			
— in living parts	1%	0.1%	5%
— in dead parts	0.1%	5%	10%

The correlation is looser in the changes of the nitrogen content (Figs 5 and 6). The rate of correlation is significantly influenced by the fact, mentioned above, that the total carbohydrate and the total nitrogen concentrations during the experimental period are not constant, and the courses of their changes differ even from each other (Fig. 4).

Similarly, a positive linear regressional correlation exists between the total carbohydrate and total nitrogen contents; their correlation, however, is not close, expecially not in the dead plant parts (Fig. 7). This is in connection with the statement, already mentioned, that changes in the total carbohydrate and total nitrogen concentrations are not of the same character during the vegetation period.

When comparing the total carbohydrate and total nitrogen concentrations it can be inferred that a higher carbohydrate concentration is in general accompanied by a lower nitrogen concentration and *vice versa* (Fig. 4); however, their correlation is not linear.

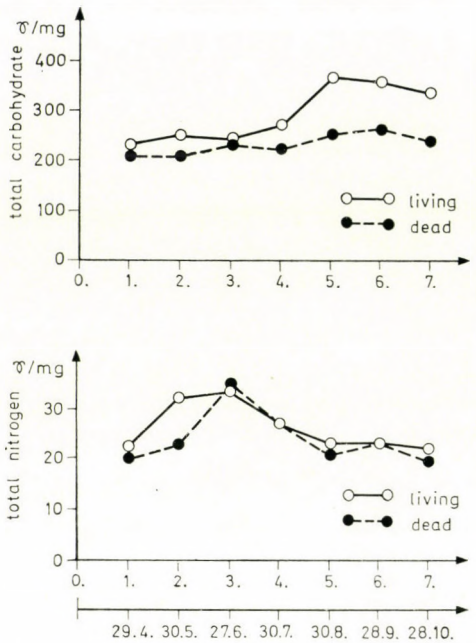


Fig. 4. Changes in the total carbohydrate and total nitrogen concentrations of the dry matter during the vegetation period

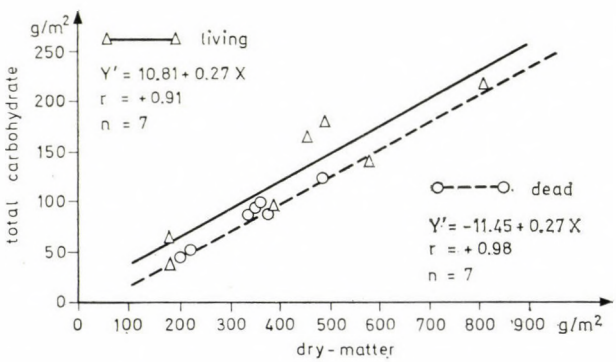


Fig. 5. Correlation between the quantities of dry matter and carbohydrate

The energy utilization of the stand in relation to the various experimental periods is given in detail in Table 5.

Up till the end of July, the stand utilized 0.79% of the global radiated energy, the highest utilization (1.03%) took place in June. In the investigation period of 128 days, the energy utilization of the stand was 0.17%.

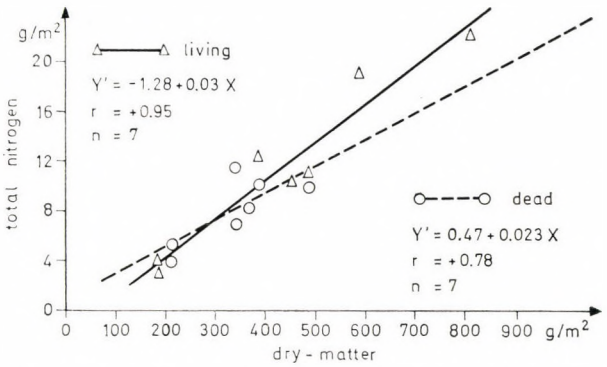


Fig. 6. Correlation between the quantities of dry matter and nitrogen

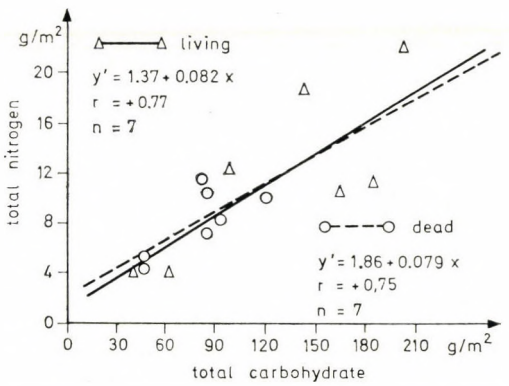


Fig. 7. Correlation between carbohydrate and nitrogen quantities

Table 5

Energy conversion of the plant stand

Period	Energy value of the production (cal/m²)	Conversion, %
IV. 29—V. 29.	854.00	0.66
V. 30—VI. 26.	1276.48	1.03
VI. 27—VII. 29.	1099.20	0.71
IV. 29—VII. 29.	3229.68	0.79
VII. 30—X. 27.	—	—
IV. 29—X. 27.	1127.76	0.17

Summary

By a monthly sampling, from the end of April till the end of October, 1974, the organic matter production and photosynthetic energy utilization of a *Salvio-Festucetum rupicolae pannonicum stipetosum capillatae* plant stand of the Mezőföld were examined. We can state as follows.

1. A majority of the dry matter content of the living parts was given throughout by *Stipa capillata;* besides it, the proportion of *Festuca rupicola* and *Salvia nemorosa* was rather significant. In the dry matter, the proportion of the dead plant parts was 42% on the average.

2. The stand increased until the end of July, and to the greatest extent in June. The total production during the whole investigation period was 281.94 g/m², representing productivity of 1.549 g/m²; 34% of this was carbohydrate and 2% was nitrogen.

3. The changes in the total carbohydrate and total nitrogen contents of the dry matter follow only partly the course of changes in the dry weight. The deviations can be explained by the changes in their concentrations during the vegetation period. The total nitrogen concentration was higher in the first half of the vegetation period while the total carbohydrate content in the second half.

4. The quantity of the dry matter of the living parts, and the carbohydrate and nitrogen contents, respectively, are in a close positive linear correlation. Concerning the dead parts, this is close in the total carbohydrate content.

5. There exists a positive linear regressional connection between the carbohydrate and nitrogen contents, but the correlation is not close.

6. It can be stated that the higher carbohydrate concentration is in general accompanied by a lower nitrogen content.

7. During its growth, from the end of April to the end of July, the stand utilized 0.79% of the radiated global energy, while in June it used 1.03% of it. As regards the whole investigation period, the energy utilization was 0.17%.

REFERENCES

ÁDÁM, L.—MAROSI, S.—SZILÁRD, J. (1959): A Mezőföld természeti földrajza (Physical Geography of the Mezőföld). Akadémiai Kiadó, Budapest.

BODROGKÖZY, GY.—HORVÁTH, I. (1969): Production examinations on plant associations of Grass-Lands with solonetz-soil. I. Effect of climatic and soil factors on dry matter, carbohydrate and nitrogen contents of Artemisio-Festucetum pseudovinae. Acta Biol. Szegediensis **15,** 3—10.

BOROS, Á. (1958): A magyar puszta növényzetének származása (Origin of the vegetation of the Hungarian puszta). Földr. Ért. 33—52.

BOROS, Á. (1959): A Mezőföld növényföldrajza (Phytogeography of the Mezőföld). Akadémiai Kiadó, Budapest, 363—383.

DUBOIS, M.—GILLES, K. A.—HAMILTON, J. K.—REBERS, P. A.—SMITH, E. (1956): Colorimetric method for determination of sugars and related substances. Anal. Chem. **28,** 350—356.

HAYASHI, K. (1966): Efficiencies of solar energy conversion in rice varieties as effected by planting density. Proc. Crop. Sci. Soc. Japan **35,** 205—211.

HORVÁTH, I. (1972): A fotoszintézis termékeinek a vizsgálata, összefüggésben a szervesanyag-produkcióval (Investigation of the products of photosynthesis, in relation with the production of organic matter). MTA Biol. Oszt. Közl. **15,** 71—76.

KELLEY, D. J.—HUNTER, A. S.—STENGERS, A. I. (1946): Determination of nitrogen, phosphorus, potassium and magnesium in plant tissue. Ind. Eng. Chem. Anal. **18,** 319—322.

MAROSI, S.—SZILÁRD, J. (1967): A dunai Alföld (The Plain of the Danube). Akadémiai Kiadó, Budapest.

MURATA, Y.—AKIRA, M.—KEN, M.—SHIGEMI, A. (1968): On the solar energy balance of rice population in relation to the growth stage. Proc. Crop. Sci. Soc. Japan **37,** 685—691.

ODUM, E. P. (1959): Fundamentals of Ecology (2nd ed.). Saunders, Philadelphia—London.

SOÓ, R. (1964, 1973): A magyar flóra és vegetáció rendszertani-növényföldrajzi kézikönyve I. és V. (Taxonomical and Phytogeographical Handbook of the Hungarian Flora and Vegetation. Vols I and V. Akadémiai Kiadó, Budapest.

SOÓ, R.—KÁRPÁTI, Z. (1968): Növényhatározó (Plant Identification Handbook). I—II. Tankönyvkiadó, Budapest.

SVÁB, J. (1973): Biometriai módszerek a kutatásban (Biometrial Methods in Research). Mezőgazdasági Kiadó, Budapest.

ZÓLYOMI, B. (1958a): Fitocönológiai analízis az alföldi löszhátak eredeti növénytakarójának maradványain (Phytocoenological Analysis on the Remnants of the Original Plant Cover of the Loess Plateaus in the Hungarian Plain). A II. Biológiai Vándorgyűlés előadásainak ismertetése (Review of the lectures given at the 2nd Itinerary Congress of Biology). Szeged.

ZÓLYOMI, B. (1958b): Budapest és környékének természetes növénytakarója (The natural plant cover of Budapest and its outskirts). — In PÉCSI, M.: Budapest természeti képe The Nature Pictures of Budapest). Akadémiai Kiadó, Budapest, 509—642.

ZÓLYOMI, B. (1967): Mezőföld — Természetes növényzet — (Mezőföld — Natural Vegetation). Akadémiai Kiadó, Budapest, 285—288.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1—2), pp. 51—60 (1976)

ECOLOGICAL OBSERVATIONS ON THE AQUATIC HYPHOMYCETES OF HUNGARY, II

OBSERVATIONS ON BIOTOPES OF AQUATIC HYPHOMYCETES IN SW HUNGARY

By

J. GÖNCZÖL

BOTANICAL DEPARTMENT, HUNGARIAN NATURAL HISTORY MUSEUM, BUDAPEST

(Received January 28, 1976)

The paper describes an unusual and less known habitat of aquatic Hyphomycetes — hollows in trees — in addition to the aquatic Hyphomycetes of gutters and open ditches in the area of reference.

Leaves decaying under water in these habitats were studied showing the sequence of the true aquatic Hyphomycetes and that of the so-called "aero-aquatic" — helicosporous — Hyphomycetes.

The paper further discusses and illustrates the conidia of foam sample collected from a non-aquatic and also unusual habitat.

Introduction

Earlier papers (GÖNCZÖL, 1971; 1974; 1975/a; 1975/b.) discussed the aquatic Hyphomycetes of the montane streams in the Central Hungarian Range (300—1000 m.) The aquatic biotopes examined heretofore have been mountain characterized in their majority by rapid flow, and a usually rocky bed. Smaller to larger rapids and water-falls are frequent there, causing a rapid movement at water and the formation of fresh waters rich in solved oxigen. I studied the aquatic Hyphomycetes of these mountain streams mainly in the Mountains Börzsöny for some time (1969—1975), and compared them to some extent with the material deriving from other streams of Hungarian mountains.

In the summer of 1975, I attempted for the first time to investigate the aquatic Hyphomycetes in SW Hungary. This part of the country (the comitats Zala and Vas) differs significantly from the central range in both their geographical and hydrographical conditions. This is a hilly terrain of 150—300 m height covered with sand, clay and brown forest soil, interrupted frequently by valleys. The slopes of the hills are under agriculture, while the hill tops are mainly covered with beeches, many cases mixed with chestnut *(Castanea sativa)*, while the streams are mostly hemmed in by alder *(Alnus glutinosa)*. Streams similar to those of the Central Ranges are not to be found here. The water of the ditches meandering at the feet of the hills and the water of the drains siphoning off inland waters flow slowly, they are almost stagnant, opalescent owing to their clayey or humic deposits.

Results

Foam formation on the water of the ditches under the conditions outlined above is rare. In July, 1975, I collected in the ditches for the first time. Hardly any water movement and no foam were to be found anywhere. I could not detect any aquatic Hyphomycetes spores in the water samples examined by means of sedimentation and filtration. In October, 1975, I collected for the second time in this habitat. Leaf denudation had already started and in the water there were many of decaying alder leaves. Owing to the rains which had been falling for a longer time, water was plentiful in the canals and ditches and it kept moving and I found even foam in one or two places.

The spore material found in the foam specimens was rather poor in both species and individual numbers. The most frequent was the conidium of *Tetracladium marchalianum* de Wild, similarly to the autumn samples of the alder woods in the mountain streams. The other species occurred in nearly identical frequencies, as follows:

Alatospora acuminata Ing.
Anguillospora longissima (de Wild.) Ingold
Heliscus aquaticus Ing.
Tetracladium setigerum (Grove) Ing.
Tricladium angulatum Ing.
Tricladium anomalum Ing.

Besides those enumerated above, the colourful spores of various terrestrial fungi also occurred in a rather great number; they had in all probability appeared secondarily in the water.

On the decaying alder leaves collected from the water of the canals, the spore production of *Tetracladium marchalianum* and of *Anguillospora longissima* started on the second to third day of incubation; later, at the beginning of November, the conidia of *Tetracladium setigerum* appeared in greater numbers.

According to the preliminary investigations, the aquatic Hyphomycetes of the streams of this region is much more monotonous and poorer than those of the mountain streams. Among the causes, the slow water movement, the greater richness in organic matter and the rather monotonous leaf material may have a part to play.

Seeking for further aquatic Hyphomycetes biotopes when sampling in July, 1975 I found smaller and larger holes in trees. In some of them there were not only wet, decaying detritus but also some water as well. One well accessible hole was at a height of about 1.5 m, in the trunk of a beech tree 40 cm in diameter.

The hollow was about 20 cm deep and the water reached a height of 5—10 cm. At the bottom of the hollow I found a decaying sediment of several

cm thickness, but the water above it was clear and odourless. I took a sample of some 100 ml. There was a copious material of mostly beech leaves in a state of advanced decay. I also collected some of these.

Until that time I had no information that a hole in a tree can also represent an aquatic Hyphomycetes habitat. I was astonished to find conidia in a large number in the water sample taken from the hollow tree (No. 1.), even though those were conidia of Alatospora acuminata Ingold that is one of the most widespread species over the world.

The spores of *Camposporium pellucidum* (Grove) Hughes were found in about a similarly large number. The spores of both species were sound and fresh, which proved that they might have come into existence not shortly before I found them. At a distance of a few hundred meters from this beech tree I happened on a similarly hollow tree. There was a smaller quantity of water and a thicker layer of deposit, but the conidia of *Alatospora acuminata* could be removed in masses from the water sample.

Next day I went to a farther beech forest about 30—40 km removed from the former place of sample collecting. Here I also succeeded in finding a beech tree with a large hole (No. 2), from its water, *Alatospora acuminata* and *Camposporium pellucidum* could be shown in a great number. Besides them, a few conidia, with all probability those of *Tricladium* sp., emerged from the sample (Plate II, Fig. 2).

After examining the skeletonized leaves which had been collected from the hollow trees, I found that only *Alatospora acuminata* produce spores, and even this species only with a frequency of a few individuals. On the leaf skeletons, which were kept in Petri dishes under a thin layer of distilled water and were slightly ventillated, the production of spores increased after a few days, and the spores appeared in great numbers even after two or three weeks.

I visited the tree holes in October of the same year for the second time. Denudation was in its initial phase, the weather had been chilly and rainy since some days. I succeeded in finding the trees labelled at the time of the former sample collecting (site No. 1); I took samples of water and of the decaying leaves — in the main part beech and elm tree leaves (*Fagus silvatica* and *Ulmus* sp.). In one of the tree hollows I found about the same quantity of water as on the previous occasion in summer, but this time I found the conidia of *Articulospora tetracladia* in the water sample. The leaf skeletons were incubated, similarly to those collected in summer, and after as short a time as 24 hours the mass production of *Articulospora tetracladia* could be experienced. *Articulospora tetracladia* Ing. f. *angulata* (Tubaki) Nilsson also occurred among the conidia.

In tree hollow No. 2, a great number of skeletonized beech leaves were found under a rather thin layer of water. When studying them in the field, I found only a few conidia of *Alatospora acuminata* in the small water sample

full of detritus. I put some of the leaf skeletons (mainly *Fagus silvatica* leaves) into Petri dishes and kept them under a thin layer of distilled water. On the second day I examined the material and observed the mass production of *Dactylella submersa* (Ing.) Nilsson on the leaf skeletons (Plate I, Figs 1—5).

Mass spore production could be observed only on the beech leaves. On a few other leaves (probably *Ulmus* sp., or *Carpinus betulus*) conidia developed as on frequently as merely a few individuals. The mature conidia were fusiform, basally obtuse, pedicellate, 50—60×8—10 μm (Plate I, Figs 3 and 5).

BÁNHEGYI (1962) reported the conidia of *Dactylella submersa* from mountain streams in Hungary. I saw them in stream waters only on one or two occasions; I have never found them growing on leaf skeletons. Only a few data on its range is known, although it is an INGOLD-species described rather long ago (1944). According to NILSSON, it is rather rare, though several of its habitats are known from Sweden. However, even these occurrences are known not from mountain streams but from ditches and canals with slowly moving or more or less stagnant waters. The present Hungarian data seem to confirm that this species inhabits quiet of stagnant waters. Tree hollows are an extreme example of these habitats.

Discussion

(1) Tree hollows, as habitats of aquatic Hyphomycetes, represent further information on the distribution of this group of fungi. Since both sampling sites (Nos 1 and 2) were far from any kind of flowing or stagnant waters, the probability of the fungi being transmitted directly, for example by wind, from these biotopes is small. Nevertheless, tree hollows, as extremely isolated habitats, have their own flora of aquatic Hyphomycetes and other fungi. Their connection with other aquatic and land habitats is presumably more restricted than that of streams and of stagnant waters. The origin of the flora of aquatic Hyphomycetes of these tree hollows is an interesting problem, because their connection "through the air" with the true habitats of aquatic Hyphomycetes is rather questionable, but their origin from the ground is also not free from problems.

It seems likely that a large portion of the leaves reach hollows in trees directly, without touching the ground, at the time of denudation, and it is only a smaller portion which is transmitted from the litter that has already fallen on the ground.

A further question is whether these tree hollows occasionally dry out completely, and if so how these fungi resettle them.

It is remarkable, in addition, that despite the small dimensions and nearly closed state of the tree hollows, the fungus species follow each other

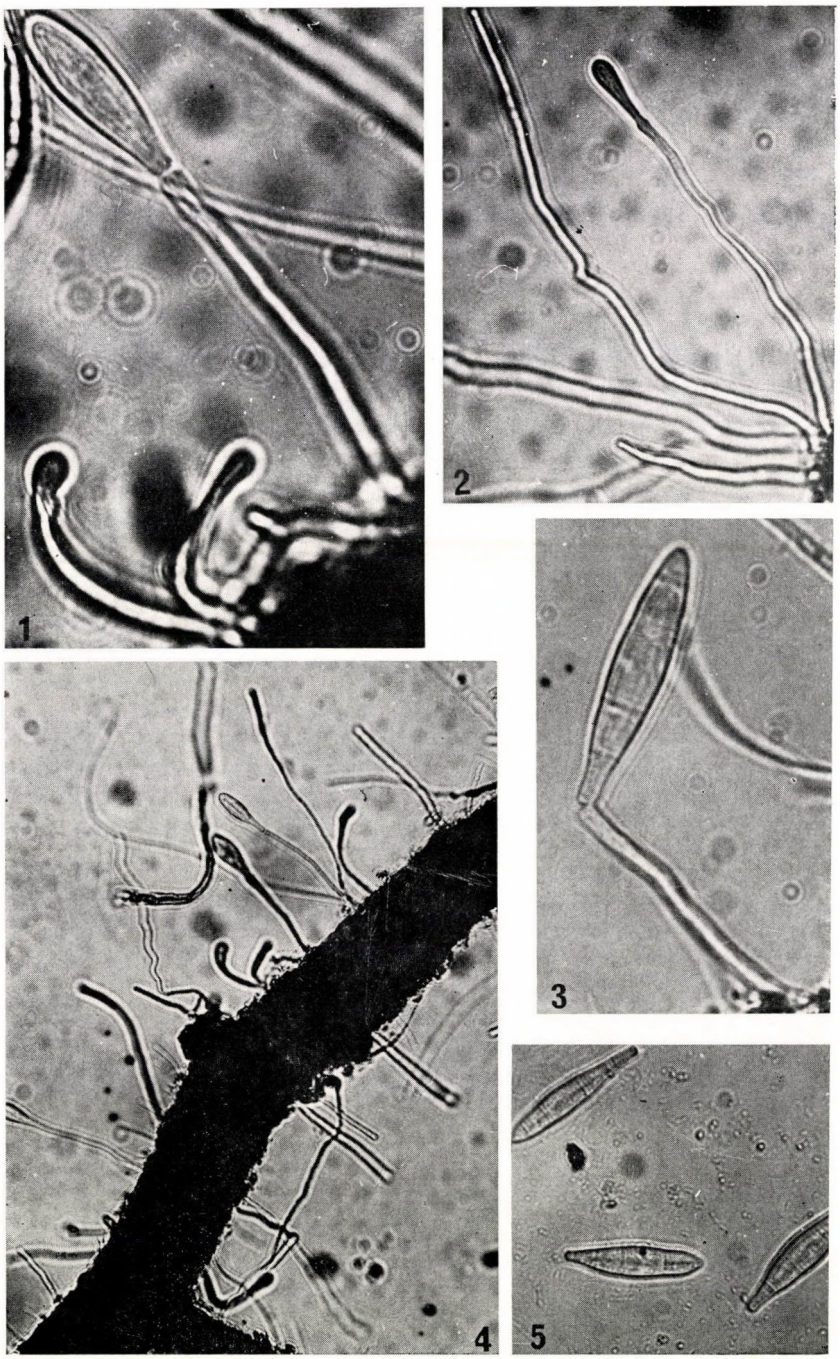


Plate I: Figs 1—2. Young conidia of *Dactylella submersa* growing on skeletonized beech leaves (×800; ×150). *Fig. 3.* Mature conidium of *Dactylella submersa* at the moment of liberation (×750). *Fig. 4.* Section of the leaf vein with the conidia of *Dactylella submersa* in various stages of development (×110). *Fig. 5.* Mature, liberated conidia of *Dactylella submersa* (×410)

periodically — similarly to the case with the "large" biotopes (those of streams and lakes) — at least the differences found in the summer and autumn samples allow this inference.

(2) There is, however, also a remarkable deviation in the sequence of the species, which I have never been able to observe on the leaves originating from streams. It could namely be observed in both the summer and the autumn material of leaf skeletons that as soon as the covering water layer subsided to such an extent that it no longer covered but still kept the leaves wet, the helicosporous Hyphomycetes appeared on them. Thus I found spiral conidia in great numbers on the leaves collected in summer (July). They probably represented *Helicodendron westerdijkae* van Beverwijk; according to their form and size, they agreed with this species. Unfortunately, all conidia was observed only in their mature, liberated state (Plate II, Fig. 5), thus their exact identification was not possible.

In the case of the species appearing on the leaf material collected in autumn (October), identification was easier, because the leaf vein network, emerging from the receding water, was almost completely covered with a greyish-green coat of a fungus, representing *Helicodendron paradoxum* Peyronel (Plate II, Figs 1, 3 and 4).

(3) The relationship between the fungus species described above and the hollow forest trees is obvious, even though their appearence in them is still unclarified.

During the sample collecting in October 1975, I succeeded in obtaining a foam sample whose place of origin was still more unusual. On the day of collecting, it rained all day, washing down, as it were, every tree of the forest. Denudation has just begun, a large part of the foliage was still on the trees.

From beech tree of magnificant size, far from all kinds of flowing or stagnant waters, a foam from the rain water accumulated at the base of the tree. From the foam sample collected there, the conidia (demonstrated in Plate III, Figs 1—9) were obtained. Some of them have already been described from stream foam. The frequency of conidia in the foam specimen did not reach the usual one from the foam of streams, but even so, 100—200 conidia could on the average be found in the water drops examined.

I could identify only the characteristic, bifurcate conidia of *Diplocladiella scalaroides* Arnaud, already well known from stream foam samples (GÖNCZÖL – TÓTH, 1974; INGOLD, 1975). Of these conidia, I found only a few specimens in one or two drops. The most frequent conidium of the sample resembled macroconidia of a Nectria sp. of 50—90×5.5—6.5 μm site (Fig. 5). I found 50—100 individuals per drop. The conidia shown in Figs 1—4 were of similar frequency. Among these, the T-shaped conidia, shown in Figs 1—2, was observed on one occasion also in a stream foam sample. They are surely identical with the type described by MIURA (1974, p. 295; Fig. 27).

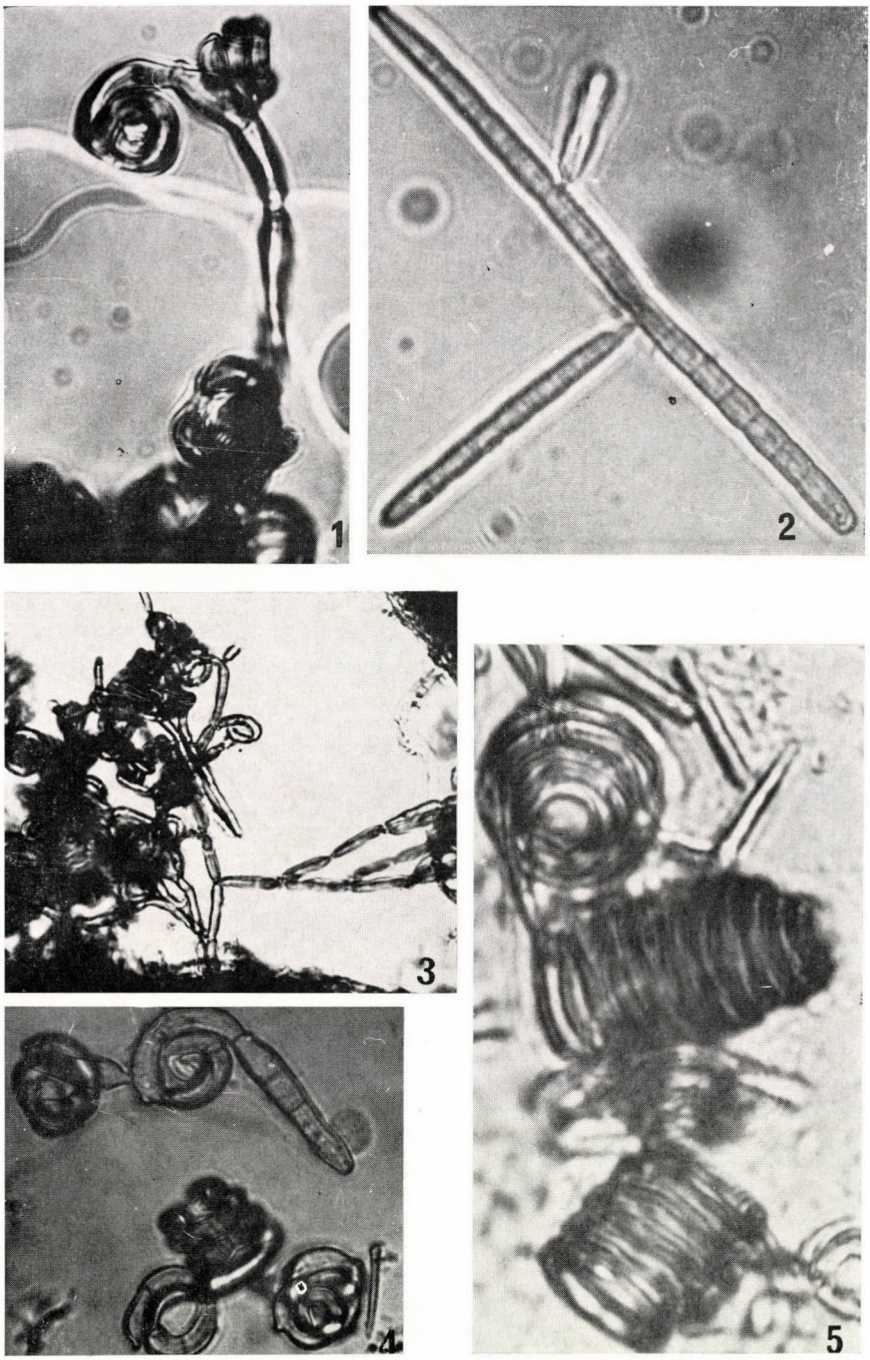


Plate II: Figs 1 and *3.* Conidiophore of *Helicodendron paradoxum* Peyronel, with growing and mature conidia (×850; ×230). *Fig. 2.* Conidium of *Tricladium* sp. found in the water of a tree hollow (×900). *Fig. 4.* Liberated mature conidia of *Helicodendron paradoxum* (×850). *Fig. 5.* Mature conidia of *Helicodendron westerdijkae* van Beverwijk (×1000)

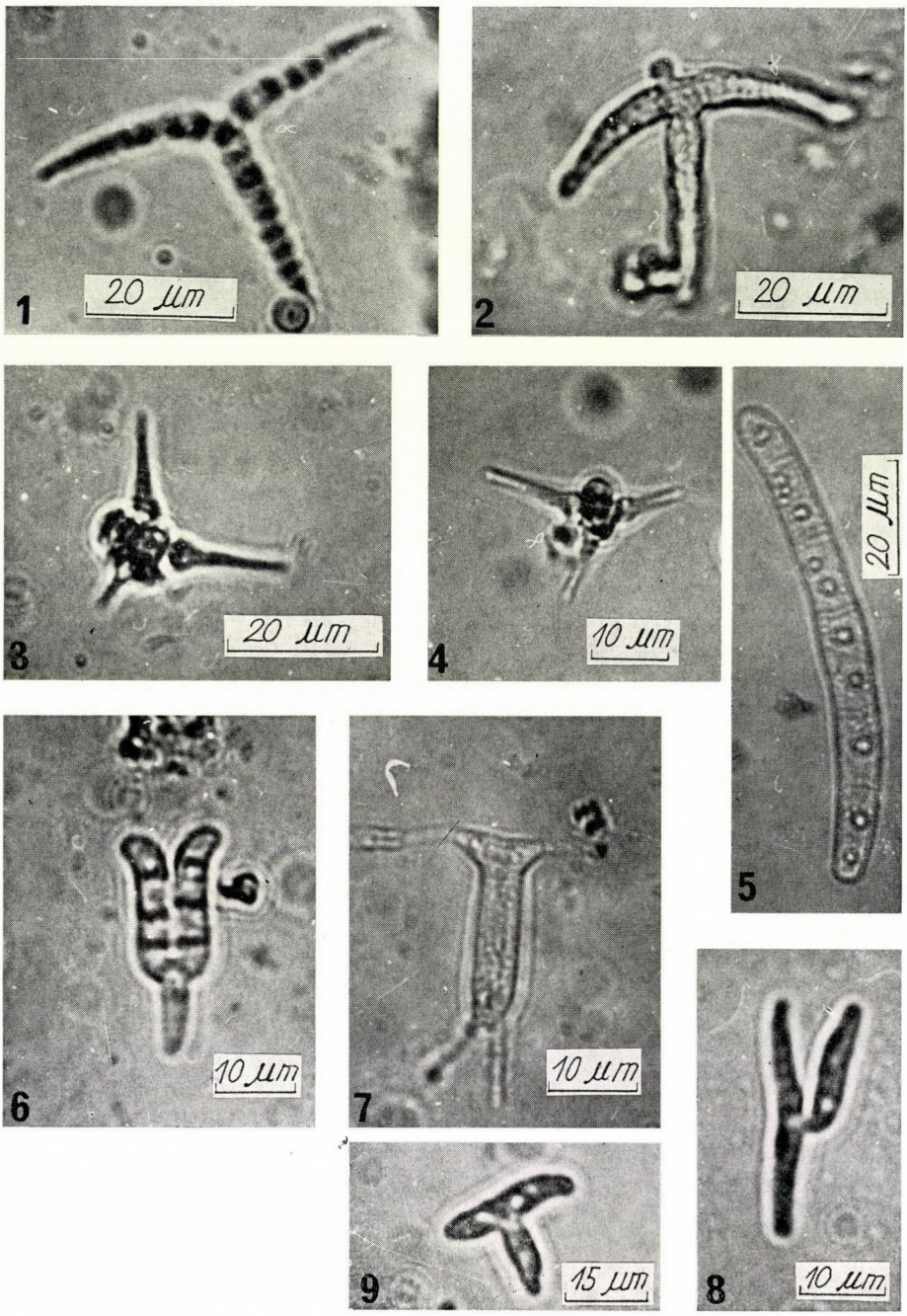


Plate III: Figs 1—9. Conidia found in the foam of rainwater washing down a beech tree

On the basis of their frequency of occurrence, the spore types shown in Figs 3 and 4 follow. I am not quite sure whether they are fungi. In their form and size they were similar to the type shown by MIURA (1974, p. 302; Fig. 85).

A few representatives of the types shown in Figs 6 and 7 occurred consistently in each of the drops examined, but more rarely than those of the former types. In Fig. 7, the representative of a conidium is presumably identical with those described by MARVANOVÁ and MARVAN (1963, p. 114; Fig. 6), and by MIURA (1974, p. 297, Fig. 53). The types shown in Figs 8 and 9 could be seen only a few times. The former one may possibly represent a *Volucrispora* sp.

Summary

Four aquatic Hyphomycetes (*Alatospora acuminata*, *Articulospora tetracladia*, *Dactylella submersa*, *Tricladium* sp.) could be demonstrated in the collected samples from a relatively rare habitat *i.e.* tree hollows; this biotope is unusual for these fungi. In addition, in the water of tree hollows also a terrestrial fungus appeared (*Camposporium pellucidum* (Grove) Hughes) which occurs — not rarely — also in stream foams (GÖNCZÖL – TÓTH, 1974; INGOLD, 1975). According to the observations, this fungus seems a not exclusively terrestrial type. INGOLD (1975) found it producing spores on submersed alder leaves. Its occurrence in the water of tree hollows in Hungary also corroborates its aquatic life form in certain conditions. The rather frequent occurrence in a relatively small number of samples of conidial types, outlined briefly in (3) of the Discussion, allows the inference that their presence there is not accidental but somehow connected with the living tree. Their introduction from the soil or eventually from the litter is hardly likely, since they accumulated in the foam deriving from the rain which watered the foliage, branches and trunk of the tree.

In recent years some observations were published which proved the land occurrence (on the ground, on decayed and living plants) of fungus species which formerly had been assumed to be aquatic: most recently PARK (1974) published the list of these species. At the same time, in the course of investigating aquatic Hyphomycetes also fungus species were found which, though hitherto regarded as terrestrial, grow well and produce spores when covered with water *(Camposporium pellucidum, Diplocladiella scalaroides)*.

These observations call attention to the fact that, according to our present knowledge, the border between aquatic and terrestrial Hyphomycetes is far from being clarified.

REFERENCES

BEVERWIJK, A. L. van (1953): Helicosporous Hyphomycetes I. Trans. Brit. Mycol. Soc. **36,** 111—125.

ELLIS, M. B. (1971): Dematiaceous Hyphomycetes, C. M. I. Kew, pp. 608.

GÖNCZÖL, J. (1971): Aquatic Hyphomycetes from the Mts. Börzsöny. Ann. Hist.-nat. Mus. Nat. Hung. **63,** 57—75.

GÖNCZÖL, J.—TÓTH, S. (1974): Rare or interesting conidia from streams of Hungary. Bot. Közl. **61,** 25—35.

GÖNCZÖL, J. (1975): Ecological observations on the Aquatic Hyphomycetes of Hungary. I. Acta Bot. Acad. Sci. Hung. **21,** 243—264.

GÖNCZÖL, J. 1976: Monotosporella tuberculata, a new species of Aquatic Hyphomycetes from Hungary. Nova Hedwigia. 27./1—2. 493—500.

INGOLD, C. T. (1944): Some new aquatic Hyphomycetes. Trans. Brit. Mycol. Soc. **27,** 35—47.

INGOLD, C. T. (1975): Guide to Aquatic Hyphomycetes. Freshwater Biological Association, **30,** 5—96.

MARVANOVA, L.—MARVAN, P. (1963): Nekolik hyfomycetü z tekoucich vod Hrubeno Jeseniku (Einige Hyphomyceten aus den fliessenden Gewässern des Hruby Jesenik). Acta Mus. Siles. Ser. A. **12,** 105—118.

MIURA, K. (1974): Stream Spora of Japan. Trans. Mycol. Soc. Japan **15,** 289—308.

NILSSON, S. (1964): Freshwater Hyphomycetes. Taxonomy, morphology and ecology. Symb. Bot. Upsal. **18,** 1—130.

PARK, D. (1974): Aquatic Hyphomycetes in non-aquatic habitats. Trans. Brit. Mycol. Soc. **63,** 183—187.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1—2), pp. 61—78 (1976)

SPATIAL DEPENDENCE OF PLANT POPULATIONS PART I. EQUIVALENCE ANALYSIS (AN OUTLINE FOR A NEW MODEL)

P. JUHÁSZ-NAGY

DEPARTMENT OF PLANT TAXONOMY AND ECOLOGY, EÖTVÖS L. UNIVERSITY, BUDAPEST

(Received February 1, 1976)

Traditional terms and methods cannot cover many aspects of spatial dependence of natural populations. (Spatial dependence includes such old terms as "association between species", "interspecific correlation", "sample similarity" as well.) This series of papers is aimed at presenting a number of new models which may provide a better insight into some neglected problems. Special emphasis is put on a space-dynamic approach (*i.e.* on some spatial processes). Our first model is concerned with a certain generalization of the attribute duality principle.

0. Primary discussion

0.1 In an excellent review, GOODALL has recently summed up a huge number of studies on "sample similarity and species correlation". This important paper (GOODALL, 1973) makes quite unnecessary to repeat here many established results, and makes possible to pay more attention to certain future tasks. GOODALL, in one of his main concluding remarks (p. 141), wrote that ". . . there is nothing absolute about correlation between species — it is entirely context-dependent". Indeed, after too long a period of pioneering work, it is high time to study the manyfold sources and problems of context-dependence. This, to say the least, is not going to be an easy job.

0.2 In the first place, our terminology is quite inadequate to the comparative work that must be performed. Even our most fundamental terms are vague and ambiguous, *in praxi*.

0.2.1 "Correlation", for instance, cannot be such a central concept as it is suggested by the title and wording of GOODALL's paper. As it is well known, two random variables, X and Y, may be dependent and yet uncorrelated [$\varrho(X, Y) = 0$], because correlation is restricted to the *linear* dependence of X and Y (cf. *e.g.* FELLER, 1957, p. 222). This restriction has the heuristic implication that "interspecific correlation" is somehow a subcase of "association between species" (a non-parametric measure of local dependence). Association, however, has a number of serious restrictions of other types. Disregarding at the moment either the controversial usage of this term in statistics (KENDALL—STUART, 1963—67; MAXWELL, 1961), or some rather special meaning attached to it (*e.g.* VOLTERRA, 1926, p. 33—), we may

confine our attention to a single ecological convention. Association is traditionally connected with "quadrat methods" (*i.e.* methods implying geometric measures); this is why PIELOU (1961, 1969) has introduced her important concepts of segregation and symmetry (connected with plotless methods). It is clear that all these terms (like "correlation", "association", "segregation") do represent different aspects of a more general concept, say, "interlocal dependence" of populations.

0.2.2 According to a metaphor used by GOODALL, interlocal dependence is just one side of the coin. The other side of it may said to be "interfloral dependence", provided that our sampling procedure is of the binary (floristic) type.* If this is not the case, then we have simply no acceptable term for covering the attribute dual relations of interlocal dependence. "Sample similarity" is a dubious term for several reasons. First, interlocal dependence may be regarded as sample similarity as well, provided that we use the term "sample" in a proper way (cf. WILKS, 1962). Secondly, the world "similarity" has a number of different meanings (JARDINE—SIBSON, 1971). Thirdly, it would be highly desirable, if our terms were able to express the attribute dual relations.

0.3 This possible confusion of meaning is, however, a minor problem compared with the difficulty of establishing how a given model is related to a certain aspect of a given phenomenon. Context-dependence is, in fact, model-dependence to a considerable extent. The basic trouble is that our ability of comparing results gained by different models but applied to the same object is extremely limited. This limitation is due to several reasons. One of these is that we have still very few relevant models. We use frequently *ad hoc* "indices", instead of using functions with well-known properties. We know very little of the "sensitivity regions" of our models, and, consequently, of how models are related to certain classes of models. We have such classes of models as "structural models", "classificatory models", "systems models", and so on. (Of course, we may think of classes of other types, like "models of ANOVA", "non-parametric models", etc.)

0.4 "Context-dependence" in the present context refers mainly to "structural models". The function of these models is to represent spatio-temporal and "abstract" (*e.g.* topological) structures of ecological phenomena. There is a striking weakness of the present-day structural modelling. Note that from the mid-sixties on (due mainly to the starting period of IBP, and to the world-wide fashion of systems modelling and ordination) very few attention has been paid to developing new structural models. The results of this eclipse are just deplorable. We are in complete ignorance of the scale-de-

* The term "spatial dependence" in the title of this paper includes both interlocal and interfloral similarity.

pendence of "non-physiognomic" structures. We know next to nothing of the precise change of spatial dependence during the successional processes. We are unable to cope with the difficult problems of "patchy environment" (PIANKA, 1974). There are very few papers, indeed, which would emphasize even the most elementary relations of spatial processes (*e.g.* JUHÁSZ-NAGY, 1967a; NOY-MEIR et al., 1970; FEKETE—SZŐCS, 1974).

0.5 The aim of this series of papers is to study certain neglected problems of context-dependence. According to the rudimentary remarks made above, this intention should imply several things (*e.g.* propositions of new concepts and models, investigations on the sensitivity regions of old and new models, etc.). Special emphasis is put on some spatial processes and other "factual evidence" of context-dependence. The series is not attempted, however, to being systematic or comprehensive in any sense.

I. Praeambulum

I.1 The present paper gives a brief outline of a simple model. Some use of the the model will be discussed in the second part of this series.

I.2 In order to show some simple features of our present problems, let us consider the following well-known tables:

	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	Σ ⟨1⟩	Σ ⟨0⟩
a	1	1	1	1	1	0	1	0	6	2
b	1	0	1	1	0	1	0	1	5	3
c	0	1	1	0	0	1	0	1	4	4
d	0	0	1	0	0	1	0	1	3	5
Σ ⟨1⟩	2	2	4	2	1	3	1	3	18	14
Σ ⟨0⟩	2	2	0	2	3	1	3	1	14	

(I; 1)

α	⟨1⟩	⟨0⟩	Σ
⟨1⟩	f⟨11⟩	f⟨01⟩	f⟨.1⟩
⟨0⟩	f⟨10⟩	f⟨00⟩	f⟨.0⟩
Σ	f⟨1.⟩	f⟨0.⟩	f⟨..⟩

β	*b*		Σ
c	3	1	4
	2	2	4
Σ	5	3	8

(I; 2)

I.2.1 Table (I; 1) is called here *a floristic composition*,* where row elements represent *a floral universe*, a basic set of local plant populations,

* "Composition", "species composition", "floristic composition" etc. is used most frequently for a list (a *set*) of plant populations. This jargon seems to be quite idiotic for the simple reason that no set of colours, symbols etc. is able to represent the composition of any non-single object (say, that of a piece of art). Composition is always an *arrangement* (a "basic structure") of some kind; it is rather *a set of relations*, instead of being a set of single objects (or their attributes).

$Q = \{a, b, c, d\}$, and column elements stand for a set of sampling units (say, "quadrats"), $T = \{t_1, t_2, \ldots, t_8\}$. Each entry of (I; 1) is an outcome of a binary relation, either "presence" ($\langle 1 \rangle$) or "absence" ($\langle 0 \rangle$) of a population in a sampling unit. Such an outcome is an elementary ("atomic") event of a sampling experiment. Binary row vectors of (I; 1) are called *local vectors* representing "*local behaviour*" of elements of Q in terms of ordered set $\widetilde{T}$. Binary column vectors are called *floral vectors* representing "*floral behaviour*" of elements of T in terms of ordered set $\widetilde{Q}$. Accordingly, row and column marginals are called *local* and *floral marginals*, respectively. Further, in both pairs of marginals there is a *valence distribution* (due to event $\langle 1 \rangle$) and an *invalence distribution* (due to event $\langle 0 \rangle$). The grand totals of valence and invalence values are called *total valence* and *total invalence*, respectively.

I.2.2 Tables in (I; 2) stand for the usual 2×2 tables, where pairs of vectors of (I; 1) are to be compared and tested usually for stochastic independence. The degree of "dependency" (*i.e.* non-independence) is usually called "similarity" (or, better, "dissimilarity") between the particular vectors. Such a comparison implies a 4-tet of "molecular events" ($\langle 11 \rangle$, $\langle 10 \rangle$, $\langle 01 \rangle$, $\langle 00 \rangle$) as it is shown in table α, where f $\langle 11 \rangle$, f $\langle 10 \rangle$, ... is the frequency of the particular event. Table β presents a special case of α, where "interlocal similarity" (*vulgo*, association) between local behaviour of b and c can be studied by some suitable function.

I.3 Pairwise comparison of this kind is always convenient and useful, in particular for classificatory purposes (see WHITTAKER, 1973). It has, however, some serious drawbacks as well. (Besides, there is no theoretical basis for saying that comparison of 3-tets, 4-tets, . . is "less natural" than that of 2-tets.) Indeed, we cannot draw any inference from a pairwise comparison as to the partial and multiple relations among components of Q or T (JUHÁSZ-NAGY, 1967b). The same is true for some measure of "overall dissimilarity" (JUHÁSZ-NAGY—DÉVAI—HORVÁTH, 1973).

I.3.1 Suppose we are interested in such a multiple measure and in one neglected aspect of local behaviour. In constructing β of (I; 2) we neglect entirely floral marginals. The question arises how this relation between floristic vectors and dual marginals can be taken into account.

I.3.2 Let us introduce the notion of *equivalence* of elementary events in terms of valence values. Outcomes of (I; 1) are said to be equivalent if and only if they are related to the same object (element of Q or T) and have the same dual valence (or invalence) values.

I.3.3 Consider, for instance, the event $\langle 1 \rangle$ related to population d in (I; 1). Two outcomes (in t_6 and t_8) are equivalent to each other (having the same floral valence value, 3) but the third outcome (in t_8) is not equivalent to the others, because its floral valence is 4. Following this line of making distinction between equivalent and non-equivalent outcomes, we can

transform table (I; 1) into a 4×4 table presented below

	1	2	3	4	Σ
a	2	3	0	1	6
b	0	2	2	1	5
c	0	1	2	1	4
d	0	0	2	1	3
Σ	2	6	6	4	18

(I; 3)

(I; 3) is called a $\langle 1 \rangle$-*equivalence table* [with respect to (I; 1)].

I.3.4 Similarly, for event $\langle 0 \rangle$ and floral invalence values of (I; 1) we can get a $\langle 0 \rangle$-*equivalence table* as follows

	1	2	3	4	Σ
a	2	0	0	0	2
b	0	1	2	0	3
c	0	2	2	0	4
d	0	3	2	0	5
Σ	2	6	6	0	14

(I; 4)

I.4 How can one draw some inference from tables (I; 3) and (I; 4)? — this is the problem of the present paper. The nature of data suggests a simple model based on information theory. For the sake of a fairly concise treatment, first a more precise notation is to be introduced.

II. Notation

II.1 Let τ_y be a stand area of a certain plant community whose flora is $Q_y = \{q_1, q_2, \ldots, q_e, \ldots, q_s\}$. Q_y is regarded to be a basic (universal) set and called floral universe as before. Let T_j be a set of sampling units ("plots") of geometric size j, $T_j = \{t_{j1}, t_{j2}, \ldots, t_{jg}, \ldots, t_{jm}\}$. Elements of T_j are randomized over τ_y. It is assumed that $m \to \infty$. By confining the term "presence" (and, of course, "absence") to a relation between τ_y and Q_y, let n_{ejg} be a binary relation (namely, an indicator function) such that

$$n_{ejg} = \begin{cases} 1, & \text{if } q_e \text{ is coincident with } t_{jg}, \\ 0, & \text{if } q_e \text{ is incoincident with } t_{jg}, \end{cases} \qquad \text{(II; 1)}$$

where coincidence means that q_e is an element of the flora φ_{jg} (*i.e.* the flora

of t_{jg}). Thus, a floristic composition, K_j, is given by

		$t_{j1}, \ldots, t_{jg}, \ldots, t_{jm}$	Σ $\langle 1 \rangle$	Σ $\langle 0 \rangle$
	q_1			
	.			
	.			
	.			
	q_e	n_{jeg}	$n_{je\cdot}$	$\tilde{n}_{je\cdot}$
	.			
	.			
	.			
	q_s			
Σ	$\langle 1 \rangle$	$n_{\cdot jg}$	N_j	n_j
	$\langle 0 \rangle$	$\tilde{n}_{\cdot jg}$	n_j	ms

(II; 2)

which is, of course, a "general form" of (I; 1). It is always assumed that $m \gg s$.

II.1.1 The following simple terminology is proposed:

— $n_{je\cdot}$ is local valence of q_e in K_j,
— $\tilde{n}_{je\cdot}$ is local invalence of q_e in K_j,
— $n_{\cdot jg}$ is floral valence of t_{jg} in K_j,
— $\tilde{n}_{\cdot jg}$ is floral invalence of t_{jg} in K_j,
— N_j is total valence of K_j,
— n_j is total invalence of K_j.

II.1.2 Let

$$V_j^{(q)} = \{n_{j1\cdot}, n_{j2\cdot}, \ldots\}$$
$$v_j^{(q)} = \{\tilde{n}_{j1\cdot}, \tilde{n}_{j2\cdot}, \ldots\}$$
$$V_j^{(t)} = \{n_{\cdot j1}, n_{\cdot j2}, \ldots\}$$
$$v_j^{(t)} = \{\tilde{n}_{\cdot j1}, \tilde{n}_{\cdot j2}, \ldots\}$$

as frequency distributions of valence and invalence data of K_j, respectively.

II.2 Suppose that there is a class of sets of sampling units Θ; laid-out over $\tau_y, \Theta; = \{T_1, T_2, \ldots, T_j, \ldots, T_u\}$, such that

$$\langle a \rangle \quad t_{1g} \subset t_{2g} \subset \ldots \subset t_{jg} \subset \ldots \subset t_{ug},$$
$$\langle b \rangle \quad t_{1g} < t_{2g} < \ldots < t_{jg} < \ldots < t_{ug}.$$

Conditions $\langle a \rangle$ and $\langle b \rangle$ are satisfied simultaneously if, for intance, we have concentric and monotonously increasing circular plots as sampling units. In this case, to each element of Θ a floristic composition can be attached.

The resulting set of compositions, $\{K_1, K_2, \ldots, K_j, \ldots, K_u\}$, has a number of monotonity properties (*e.g.* $N_1 < N_2 < \ldots < N_j < \ldots N$; $n_1 > n_2 > > \ldots > n_j > \ldots$). The spatial processes connected with $K_1 \to K_2 \to \ldots \to \to K_j \to \ldots$ are approximated, for instance, by proper function defined on frequency distributions of II.1.2.

II.3 Let R be a discrete random variable for the possible values of floral valence; $R = 0, 1, 2, \ldots, r, \ldots, s$. Let g_{jr} be the frequency of the value r $[(R = r)]$ in K_j, and $n_{.jr} = rg_{jr}$. With this notation in hand, we have

	..... r	Σ
q_e	n_{jer}	$n_{je.}$
Σ	$n_{.jr}$	N_j

(II; 3)

which, of course, is a "general form" of (I; 3). A similar general form is gained easily for (I; 4) by denoting $\tilde{r} = s - r$, $\tilde{r}g_{jr} = \tilde{n}_{.jr}$, from which we have (II; 4)

	..... $\tilde{r}$	Σ
q_e	$\tilde{n}_{jer}$	$\tilde{n}_{je.}$
Σ	$\tilde{n}_{.jr}$	n_j

(II; 4)

II.4 For immediate use, let

$$\sum_e n_{je.} \log n_{je.} = A_j, \qquad \sum_e \sum_r n_{jer} \log n_{jer} = D_j,$$

$$\sum_e \tilde{n}_{je.} \log \tilde{n}_{je.} = a_j, \qquad \sum_e \sum_r \tilde{n}_{jer} \log \tilde{n}_{jer} = d_j,$$

$$\sum_g n_{.jg} \log n_{.jg} = B_j, \qquad \sum_r n_{.jr} \log n_{.jr} = E_j,$$

$$\sum_g \tilde{n}_{.jg} \log \tilde{n}_{.jg} = b_j, \qquad \sum_r \tilde{n}_{.jr} \log \tilde{n}_{.jr} = e_j,$$

$$N_j \log N_j = C_j,$$

$$n_j \log n_j = c_j.$$

II.5 Contingency information of (II; 3) and (II; 4) is given by (II; 5) and (II; 6), respectively,

$$N_j\hat{I}_j(E) = C_j - A_j - E_j + D_j\,, \qquad \text{(II; 5)}$$

$$n_j\hat{I}_j(e) = c_j - a_j - e_j + d_j\,. \qquad \text{(II; 6)}$$

$N_j\hat{I}_j(E)$ is called $\langle 1\rangle$-equivalence information, and $n_j\hat{I}_j(e)$ is called $\langle 0\rangle$-equivalence information. Consult KULLBACK (1959) for a proper foundation of the concept "contingency information".

III. An additive relation

III.1 Let us define the following pair of quantities

$$N_j\hat{I}_j(K) = C_j - A_j - B_j\,, \qquad \text{(III; 1)}$$

$$n_j\hat{I}_j(k) = c_j - a_j - b_j\,. \qquad \text{(III; 2)}$$

(III; 1) is called *coincidence information* [with respect to events $\langle 1\rangle$ of (II; 2)] and (III; 2) is called *incoincidence information* [with respect to events $\langle 0\rangle$ of (II; 2)].

III.2 In order to relate (III; 1) to (II; 5) [and, *mutatis mutandis*, (III; 2) to (II; 6)] a simple trick is introduced by decomposing table (II; 2) into a number of subcontingency tables according to the particular values of variable R. This procedure can easily be demonstrated by our fictious and oversimplified data of I. By decomposing table (I; 1) into a set of proper subtables, we have

$(R=1)$			$(R=2)$				$(R=3)$			$(R=4)$		
t_5	t_7		t_1	t_2	t_4		t_6	t_8		t_3		
1	1	2	1	1	1	3	0	0	0	1	1	
0	0	0	1	0	1	2	1	1	2	1	1	(III; 3)
0	0	0	0	1	0	1	1	1	2	1	1	
0	0	0	0	0	0	0	1	1	2	1	1	
1	1	2	2	2	2	6	3	3	6	4	4	

It is easy to see that row marginals of (III; 3) correspond exactly to columns of (I; 3), that is we have the following "general subtable"

	$(R=r)$	Σ	
q_{je}	.....	n_{jer}	(III; 4)
Σ	$\underbrace{r \ldots\ldots r}_{g_{jr}}$	$n_{\cdot jr} = rg_{jr}$	

where g_{jr} (as in II.3) is the frequency of value r in $V_j^{(t)}$.

III.3 Let us define the sum of weighted information contents of such a complete series of tables like that in (III; 3) as

$$\left.\begin{aligned}\hat{Y}_j &= \sum_{r=0}^{s} rg_{jr} \log rg_{jr} - \sum_{r=0}^{s} g_{jr}\, r \log r - \sum_{r=0}^{s} n_{jer} \log n_{jer} \\ &= E_j - B_j - D_j.\end{aligned}\right\} \qquad \text{(III; 5)}$$

$\hat{Y}_j$ is called *subcoincidence information* of a K_j. From (II; 5) and (III; 5) we see that

$$\left.\begin{aligned}N_j\hat{I}_j(K) - \hat{Y}_j &= C_j - A_j - B_j - E_j + B_j + D_j \\ &= C_j - A_j - E_j + D_j \\ &= N_j\hat{I}_j(E),\end{aligned}\right\} \qquad \text{(III; 6)}$$

that is, in words, coincidence information minus subcoincidence information equals to $\langle 1\rangle$-equivalence information of a K_j. *Mutatis mutandis*,

$$n_j\hat{I}_j(k) - \hat{y}_j = n_j\hat{I}_j(e), \qquad \text{(III; 7)}$$

a similar relation is true for $\langle 0\rangle$-equivalence information of a K_j. In the sequel we use mostly (III; 6) for detecting some properties of equivalence information.

III.4 As a simple illustration let table (I; 1) be taken as a "true" K_j (disregarding problems of sampling, etc.) for which

$$A_j = 39.874\,, \qquad B_j = 29.509\,, \qquad C_j = 75.058\,,$$
$$D_j = 14.755\,, \qquad E_j = 41.019\,,$$

where each quantity is given in weighted *bits*. According to (III; 1), $N_j\hat{I}_j(K) = 75.058 - 63.383 = 11.675$. From (III; 3), $\hat{Y}_j = 2.755$. Thus, following our key relation in (III; 6), $N_j\hat{I}_j(E) = 11.675 - 2.755 = 8.920$. The same result is given by estimating information content of table (I; 3) by (II; 5),

$$N_j\hat{I}_j(E) = 75.058 - 39.874 - 41.019 + 14.755 = 8.920.$$

Similarly,

$$a_j = 26.364, \qquad b_j = 15.509, \qquad c_j = 53.302,$$
$$d_j = 14.755, \qquad e_j = 33.019.$$

$n_j\hat{I}_j(k) = 53.302 - 41.873 = 11.429$, and $\hat{y}_j = 2.755$. According to (III; 7), $n_j\hat{I}_j(e) = 11.429 - 2.755 = 8.674$. The same result is given by estimating information content of table (I; 4),

$$n_j\hat{I}_j(e) = 53.302 - 26.364 - 33.019 + 14.755 = 8.674.$$

IV. Special cases

IV.1 In order to study the additive relation in (III; 6) more closely, let us consider a few relevant cases under some idealized conditions. Although most of these cases are quite irrealistic (in the sense that they are unexpected in any "real situation"), they hopefully provide a better understanding of "natural trends" of $N_j\hat{I}_j(E)$. Instead of following a rather abstract line of reasoning, the treatment is confined to a few heuristic points.

IV.2 Suppose that in a spatial process (see II.2), when $K_1 \rightarrow K_2 \rightarrow \rightarrow \ldots \rightarrow K_j \rightarrow \ldots$, we think of the change of the compositional *states*. Suppose, further, that some special (*e.g.* "regular") states are to be distinguished at any point of the process.

IV.2.1 A K_j is said to be

— (1) in an *f-monovalence state* (or, in brief, in an *f-state)*, when $n_{.jg} = N_j/m = \bar{s}_j$, for $g = 1, 2, \ldots, m$,

— (2) in an *l-monovalence state* (or, in brief, in an *l-state)*, when $n_{je.} = N_j/s = \bar{m}_j$, for $e = 1, 2, \ldots, s$,

— (3) in an *F-oligovalence state* (or, in brief, in an *F-state)*, when $g_{js} = \bar{m}_j$,

— (4) in an *L-oligovalence state* (or, in brief, in an *L-state)*, when $h_{jm} = \bar{s}_j$,

where h_{jm} is the frequency of m-valued local valences in $V_i^{(q)}$. $\bar{s}_j$ and $\bar{m}_j$ are called *floral* and *local density*, respectively. Note that $\bar{s}_j$ and $\bar{m}_j$ (as arithmetic means of $V_j^{(t)}$ and $V_j^{(q)}$) always exist and important without regularity of any kind but assumptions (1)—(4) represent special cases with respect to the dispersion of valence data. In the monovalence states there is a minimum (zero) dispersion, and, on the other hand, in the oligovalence states there is a maximum dispersion around the particular mean.

IV.2.2 By using (1)—(4), K_j is said to be

— (5) in an *f-L-state*, when both (1) and (4) are satisfied,

— (6) in an *F-l-state*, when both (3) and (2) are satisfied,

— (7) in an *f-l-state*, when both (1) and (2) are satisfied.

Note that an *F-L-state* [when both (3) and (4) are satisfied] is always impossible. In other words, (5) and (6) are obligatory in the sense that once single assumptions (3) or (4) are established, then dual valence distributions are fixed [*i.e.* (3) should occur with (2), and (4) should occur with (1)]. On the other hand, single assumptions (1) and (2) may occur with no such restrictions, and, for this reason, a K_j is said to be

— (8) in a *single f-state*, when (1) is satisfied regardless of $V_j^{(q)}$,

— (9) in a *single l-state*, when (2) is satisfied regardless of $V_j^{(t)}$.

IV.2.3 Note that in all assumptions made above at least two points need further comment. First, it is assumed that $\bar{s}_j$ and $\bar{m}_j$ are integers; in the

majority of "real cases" both $\bar{s}_j$ and $\bar{m}_j$ are real numbers. This simplification is justified, however, by the utmost simplicity of relations in IV.3 that are not influenced by such a distinction. Second, it is assumed that configurations (5)—(9) are possible from a combinatorial point of view (*i.e.* binary vectors can be arranged in a such a way that a configuration would occur). Clearly, this is not always the case. Disregarding difficulties at the moment, we discuss some combinatorial point later on (V.—).

IV.3 Returning to (III; 6), let us set up four relevant cases.

[Case 1] $N_j\hat{I}_j(K) = 0$, $\hat{Y}_j = 0$, $N_j\hat{I}_j(K) = \hat{Y}_j$, and so $N_j\hat{I}_j(E) = 0$.

[Case 2] $N_j\hat{I}_j(K) > 0$, $\hat{Y}_j > 0$, $N_j\hat{I}_j(K) = \hat{Y}_j$ and so $N_j\hat{I}_j(E) = 0$,

[Case 3] $N_j\hat{I}_j(K) > 0$, $\hat{Y}_j = 0$, $N_j\hat{I}_j(K) > 0$, and so $N_j\hat{I}_j(E) = N_j\hat{I}_j(K)$.

[Case 4] $N_j\hat{I}_j(K) > 0$, $\hat{Y}_j > 0$, $N_j\hat{I}_j(K) > \hat{Y}_j$, and so $N_j\hat{I}_j(E) < N_j\hat{I}_j(K)$

IV.3.1 Conditions for [Case 1] are satisfied when K_j is
— [1a] either in an *f-L* state, or in an *F-l-state*,
— [1b] or in a "minimum area" state, where $N_j = ms$, and $\bar{s}_j = s$, and $\bar{m}_j = m$.

Note that [1b] is a special case of an *f-l*-state. Note, however, that [Case 1] is not satisfied in any other *f-l*-state than [1b]. In [1b]

$$N_j\hat{I}_j(K) = sm \log sm - sm \log m - ms \log s = 0, \qquad \text{(IV; 1)}$$

and $\hat{Y}_j = 0$, since we have only one single subtable with $(R = s)$ and $n_{.js} = N_j = ms$. In [1a], either

$$N_j\hat{I}_j(K) = m\bar{s}_j \log m\bar{s}_j - m\bar{s}_j \log \bar{s}_j - \bar{s}_j m \log m = 0\,, \qquad \text{(IV; 2)}$$

or

$$N_j\hat{I}_j(K) = s\bar{m}_j \log s\bar{m}_j - s\bar{m}_j \log \bar{m}_j - \bar{m}_j s \log s = 0\,. \qquad \text{(IV; 3)}$$

Clearly, in both subcases $\hat{Y}_j = 0$.

IV.3.2 Conditions for [Case 2] are satisfied, when K_j is
[2a] either in a single *f*-state,
[2b] or in an *f-l*-state such that $N_j < ms$.

In [2a]

$$\left.\begin{aligned} N_j\hat{I}_j(K) &= \hat{Y}_j \\ &= C_j - m\bar{s}_j \log \bar{s}_j - A_j \\ &= N_j \log m - A_j\,. \end{aligned}\right\} \qquad \text{(IV; 4)}$$

In [2b]

$$\left.\begin{aligned} N_j\hat{I}_j(K) &= \hat{Y}_j \\ &= C_j - s\bar{m}_j \log \bar{m}_j - m\bar{s}_j \log \bar{s}_j \\ &= C_j - C_j + N_j \log s - C_j + N_j \log m \\ &= N_j \log ms - C_j \\ &= N_j \log \frac{ms}{N_j}. \end{aligned}\right\} \qquad \text{(IV; 5)}$$

It is clear that if $N_j = ms$, then $N_j\hat{I}_j(K) = ms \log 1 = 0$, and so [Case 2] is collapsed into [Case 1b]. Consequently,

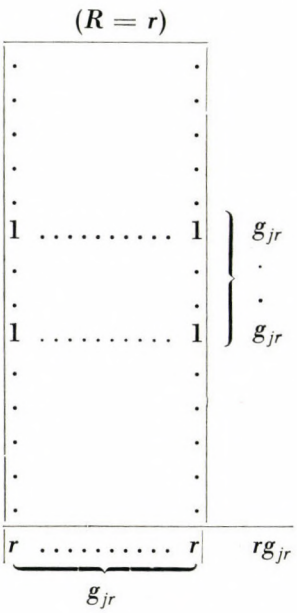
$$\text{if } N_j \to ms, \quad \text{then} \quad N_j\hat{I}_j(K) \to 0; \qquad \text{(IV; 6)}$$

this simple limiting relation will be used in the sequel (see Part II.). Note that (IV; 4) and (IV; 5) are the same if $A_j = s\bar{m}_j \log \bar{m}_j = C_j - N_j \log s$, *i.e.* if in (IV; 4)

$$\begin{aligned} N_j\hat{I}_j(K) &= N_j \log m - A_j \\ &= N_j \log m - C_j + N_j \log s \\ &= N_j \log ms - C_j, \end{aligned}$$

when [2a] is collapsed to [2b].

IV.3.3 Conditions for [Case 3] are satisfied, when the following "inner regularity"



(IV; 6)

is true for all the subcontingency tables (with $R = 1, 2, \ldots, s$) of a K_j. In this case,

$$\hat{Y}_j = \sum_r rg_{jr} \log rg_{jr} - \sum_r g_{jr} r \log r - \sum_r rg_{jr} \log g_{jr} = 0, \qquad \text{(IV; 7)}$$

and, consequently, $N_j \hat{I}_j(E) = N_j \hat{I}_j(K)$.

IV.3.4 In [Case 4] neither the "marginal regularities" of [Case 1] and, [Case 2] nor the "inner regularity" of [Case 3] are satisfied. [Case 4] is likely to be expected in any "real situation", when $N_j < ms$.

V. Floral orderliness

V.1 From III. and IV. we see that

$$0 \leq N_j \hat{I}_j(E) \leq N_j \hat{I}_j(K). \qquad \text{(V; 1)}$$

It is clear that the lower bound of (V; 1) is due to either [Case 1] or [Case 2], and the upper bound of (V; 1) is due to [Case 3]. Let us examine more closely the ecological meaning of these cases.

V.2 First of all, still following out the spirit of the previous reasoning let us consider some simple and fictitious examples.

V.2.1 As a starting point, we may ask what is the basic difference between (V;2) and (V; 3) representing [Case 7] and [Case 9], respectively.

	1	2	3	4	5	6	7	8	
a	1	1	1	1					4
b	1	1	1	1					4
c					1	1	1	1	4
d					1	1	1	1	4
	2	2	2	2	2	2	2	2	16

(V; 2)

	1	2	3	4	5	6	7	8	
a	1	1	1	1					4
b					1	1	1	1	4
c					1	1	1	1	4
d					1	1	1	1	4
	1	1	1	1	3	3	3	3	16

(V; 3)

V.2.2 This simple question is not trivial at all. Suffice it to say that the sum of pairwise association is of the same value for both cases (namely, 48 weighted bits). Suppose that we try to answer our question by means of a fairly new model (JUHÁSZ-NAGY—DÉVAI—HORVÁTH, 1973). This model is concerned with the problem of "overall association" (called, *associatum*) of

a K_j. Associatum, $m\hat{I}_j[\lambda]$, is the multiple contingency information of a $2\times2\times2\times2$ table (a table of 2^s cells, in general),

$$m\hat{I}_j[\lambda] = sm \log m - \alpha_j - m\hat{H}_j^{(\varphi)}, \qquad \text{(V; 4)}$$

where $\alpha_j = A_j + a_j$, and $m\hat{H}_j^{(\varphi)}$ is a function called *floral diversity*. Floral diversity is defined on the frequency distribution of the power set of a floral universe. More precisely, if Π_y is the power set of Q_y,

$$\Pi_y = \{\pi_1, \pi_2, \ldots, \pi_k, \ldots, \pi_\omega\}, \qquad \text{(V; 5)}$$

where $\omega = 2^s$, π_k (a *potential flora* of Q_y) is any combination of elements of Q_y (and, *per conventionem*, π_1 is the empty flora $[\pi_1 = \Phi]$, π_ω is the complete flora $[\pi_\omega = Q_y]$), then each K_j has a unique frequency distribution,

$$F_j = \{f_{j1}, f_{j2}, \ldots, f_{jk}, \ldots, f_{j\omega}\}, \qquad \text{(V; 6)}$$

where f_{jk} is the frequency of π_k in K_j, and $\sum_k f_{jk} = m$. Floral diversity then is shown to be

$$m\hat{H}_j^{(\varphi)} = m \log m - \sum_k f_{jk} \log f_{jk}. \qquad \text{(V; 7)}$$

For both (V; 2) and (V; 3), however, using still log to base 2,

$$m\hat{I}_j[\lambda] = 96 - 64 - 8 = 24.$$

On the other hand, $N_j\hat{I}_j(E) = 0$ for (V; 2), and $N_j\hat{I}_j(E) = 12.98$ for (V; 3). This shows clearly that association (or, even, associatum) is quite insensitive to certain differences in composition (if $V_j^{(q)}$ and F_j are the same), and, in particular, to the "inner regularity" of [Case 9].

V.3 The inner regularity of a K_j in IV.3.3 requires a certain kind of orderliness in composition. More precisely, a K_j is said to be *florally ordered* if and only if K_j is not in an *f*-state, and to each value of R with non-zero frequencies a unique potential flora is attached. In (V; 3), for instance, R has two values with non-zero frequencies, and $(R = 1)$ and $(R = 3)$ are represented by two unique elements of (V; 6) (namely, by "a" and "bcd"). On the other hand, K_j of (V; 2) is in an *f*-state, and $(R = 2)$ is represented by two kinds of potential floras (by "ab" and "cd"). Consequently, (V; 2) is not ordered florally, and (V; 3) has a rather high degree of floral orderliness.

V.4 The conditions of V.3 may be reversed and asked what happens when a certain kind of "perfect floral disorder" occurs. In other words, we may face a situation, where each flora of a K_j is different from any other flora.

V.4.1 Suppose that $m = 2^s$, and $f_{jk} = 1$, for $k = 1, 2, \ldots, \omega$. If, for instance, $s = 4$, $m = 16$, we have the following table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
a	0	1	0	0	0	1	1	1	0	0	0	1	1	1	0	1	8	
b	0	0	1	0	0	1	0	0	1	1	0	1	1	0	1	1	8	
c	0	0	0	1	0	0	1	0	1	0	1	1	0	1	1	1	8	(V; 8)
d	0	0	0	0	1	0	0	1	0	1	1	0	1	1	1	1	8	
	0	1	1	1	1	2	2	2	2	2	2	3	3	3	3	4	32	

The corresponding $\langle 1 \rangle$-equivalence table is shown by (V; 9)

	1	2	3	4		
a	1	3	3	1	8	
b	1	3	3	1	8	
c	1	3	3	1	8	(V; 9)
d	1	3	3	1	8	
	4	12	12	4	32	

V.2.4 In such a table as (V; 9) each row corresponds exactly to the $(s - 1)$th row of the PASCAL-triangle, that is, $n_{je\cdot} = 2^{s-1}$, $n_{\cdot jr} = s\binom{s-1}{r}$, and $N_j = s\,2^{s-1}$. We may guess that for (V; 9) $N_j \hat{I}_j(E) = 0$, and, if this is true, then

$$C_j - A_j = E_j - D_j . \qquad \text{(V; 10)}$$

For proving (V; 10), let $\binom{s-1}{r} = \sigma_r$. The left side of (V; 10) is

$$s\,2^{s-1} \log s\,2^{s-1} - s\,2^{s-1} \log 2^{s-1} = s \log s\,2^{s-1} ,$$

and the right side of (V; 10) is

$$\sum_r s\sigma_r \log s\sigma_r - \sum_r s\sigma_r \log \sigma_r = \sum_r \sigma_r\, s \log s ,$$

by which, since $s \log s$ is constant, and $\sum_r \sigma_r = 2^{s-1}$, the equality holds. Indeed, for (V; 9), $C_j = 160$, $A_j = 96$, $E_j = 102.0376$, $D_j = 38.0376$, where each quantity is expressed in weighted bits, $C_j - A_j = E_j - D_j = 4 \log 4 \cdot 8 = 64$, and, consequently, $N_j \hat{I}_j(E) = 0$.

V.4.3 It is worth remarking that a proper $\langle 0 \rangle$-equivalence table for (V; 8) corresponds exactly to table (V; 9). This correspondence is trivial [because $\binom{s}{r} = \binom{s}{s-r}$], but it has a further implication as well. Since 2^s, in most cases, is a fairly large number (*viz.* $2^{10} \approx 10^3$, $2^{20} \approx 10^6$, ..., $2^{10z} \approx \approx 10^{3z}$, for $z = 1, 2, \ldots$), the assumption made in V.4.1 ($m = 2^s$) is almost

always irrealistic. For practical reasons, if, say, $s \geqslant 10$, then we must choose m such that $m \ll 2^s$. By choosing m much smaller than 2^s, however, we may introduce artificially some unknown degree of floral orderliness into our referential system. This drawback can be compensated as a first approach by considering $N_j\hat{I}_j(E)$ and $n_j\hat{I}_j(e)$ simultaneously; this is why invalence values are as important as valence values in a K_j. A more advanced approach is to handle m ("number of quadrats") as a variable, but in this case the complementary role of $N_j\hat{I}_j(E)$ and $n_j\hat{I}_j(e)$ (or that of other functions) still holds.

V.5 The simplest way of looking at floral order is possible by considering potential floras as binary column vectors of a K_j. Such vectors (*i.e.* ordered s-tets of $\langle 1, 0\rangle$), may or may not belong to the same value of floral valence. K_j is florally ordered if the same column vector belongs always to the same value of R.

VI. Orderliness in composition

VI.1 So far the treatment has been confined to order of the floral type. Clearly, the definition of V.3 or V.5 can be generalized into

$\langle 1\rangle$ local orderliness,

and $\langle 2\rangle$ double orderliness

of a K_j. For the sake of simplicity (and for avoiding a fairly complicated symbolism), suffice it to apply some rough-and-ready demonstrations.

VI.2 Let us compare three table, (V; 3), (VI; 1), and (VI; 2).

	1	2	3	4	5	6	7	8	
a	1								1
b		1	1	1					3
c					1	1	1	1	4
d					1	1	1	1	4
	1	1	1	1	2	2	2	2	12

(VI; 1)

	1	2	3	4	5	6	7	8	
a	1	1	1						3
b				1	1	1	1	1	5
c				1	1	1	1	1	5
d				1	1	1	1	1	5
	1	1	1	3	3	3	3	3	18

(VI; 2)

VI.2.1 It has already been shown that (V; 3) is florally ordered (V.3). It is, however, not ordered locally, because different row vectors (local vectors) belong to the same value of local valence, and *vice versa*. In a reverse

way, (VI; 1) is not ordered florally [since different potential floras, "*a*" and "*b*", belong to the same value of floral valence, $(R = 1)$], but it is ordered locally. Finally, (VI; 2) is double-ordered, because both different floral and local vectors belong always to the same values of both floral and local valences.

VI.2.2 It is worth noticing at once that if K_j is double-ordered, then

$$N_j \hat{I}_j(E) = N_j \hat{I}_j(K) = C_j - E_j . \qquad \text{(VI; 3)}$$

The simplest way of proving this reduction is to show that $A_j = D_j$. By the conditions given

$$A_j = \sum_r r \; g_{jr} \log g_{jr} , \qquad \text{(VI; 4)}$$

and, using a modified version of (V; 6),

$$D_j = r \, f_{j.}^{(r)} \log f_{j.}^{(r)}, \qquad \text{(VI; 5)}$$

where $f_{j.}^{(r)}$ is frequency of a potential flora of K_j which consists of r elements of $Q_y \cdot g_{jr} = f_{j.}^{(r)}$, because each value of R belongs always to the same potential flora, and, consequently, $A_j - D_j$.

VI.3 It is straightforward again that equivalence information of the local type is equal to the dual quantity of the floral type if and only if K_j is double-ordered.

VII. Some interim remarks

VII.1 Compositional "orders" of different types are, presumably, important in many respects. It remains to be investigated, of course, how the idealized conditions of VI.—VI. are useful in understanding "real situations". Some use of the model will be discussed in the second part of this series.

VII.2 This demonstration is postponed, because we have still a number of problems to be considered. Due to limitation of space, the present paper had no opportunity to deal with the problems of spatial processes. The second part of this series should start with the statement that conditions for orderliness depend on the size of sampling units to a considerable extent.

REFERENCES

FEKETE, G.—SZŐCS, Z. (1974): Studies on interspecific association processes. Acta Bot. Acad. Sci. Hung. **20**, 227—41.

FELLER, W. (1957): An Introduction to Probability Theory and its Applications. 2nd ed. Wiley, New York.

GOODALL, D. W. (1973): Sample similarity and species correlation. In: WHITTAKER (1973), 107—156.

JARDINE, N.—SIBSON, R. (1971): Mathematical Taxonomy. Wiley, New York.
JUHÁSZ-NAGY, P. (1967a): On some "characteristic areas" of plant community stands. Proc. Coll. on Information Theory (Akadémiai Kiadó, Budapest), 269—282.
JUHÁSZ-NAGY, P. (1967b): On association among plant populations. I. Multiple and partial association: a new approach. Acta Biol. Debrecina **5,** 43—56.
JUHÁSZ-NAGY, P.—DÉVAI, I.—HORVÁTH, K. (1973): Some problems of model-building in synbiology. II. Associatum processes in a simple situation. Annal. Univ. Sci. Budapest, Sect. B. **15,** 39—51.
KENDALL, M. G.—STUART, A. (1963—67): The Advanced Theory of Statistics. Vol. I—III. 2nd. ed. Hafner, New York.
KULLBACK, S. (1959): Information Theory and Statistics. Wiley, New York.
MAXWELL, A. E. (1961): Analysing Qualitative Data. Methuen, London.
NOY-MEIR, I.—TADMOR, N. H.—ORSHAN, G. (1970): Multivariate analysis of desert vegetation. I. Association analysis at various quadrat sizes. Israel J. Bot. **19,** 561—591.
PIANKA, E. R. (1974): Evolutionary Ecology. Harper and Row, New York.
PIELOU, E. C. (1961): Segregation and symmetry in two-species populations . . . J. Ecol. **49,** 225—269.
PIELOU, E. C. (1969): An Introduction to Mathematical Ecology. Wiley, New York.
VOLTERRA, V. (1926): Variazioni e fluttuazioni del numero d'individui in specie animali conviventi. Memorie della Accad. Nat. dei Lincei, anno CCCXII, II, 1—110.
WHITTAKER, R. H. ed. (1973): Ordination and classification of vegetation. (Handbook of Vegetation Science, Part V.) Junk, The Hague.
WILKS, S. S. (1962): Mathematical Statistics. Wiley, New York.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1—2), pp. 79—84 (1976)

SHRUB LAYER PHYTOMASS INVESTIGATIONS IN THE QUERCUS PETRAEA-QU. CERRIS ECOSYSTEM OF THE SÍKFŐKÚT RESEARCH AREA*

By

I. KÁRÁSZ

BOTANICAL INSTITUTE, KOSSUTH L. UNIVERSITY, DEBRECEN

(Received October 18, 1975)

The paper contains the results of phytomass investigations made in the shrub level of the turkey-oak forest ecosystem at Síkfőkút (Síkfőkút Project). The estimation of the phytomass was performed between August and September 1973, with the "average shrub method" per sublevel, and in a break-down according to species.

Within the framework of the "International Biological Program" and of the "Man and Biosphere" research program, complex ecosystem investigations have already been launched in various research centres abroad.

Similar to them are the researches launched in the ecosystem of the Hungarian Síkfőkút turkey oak forest (Síkfőkút Project). A substantial part of these researches consists of the phytomass investigations related to structure examinations. The phytomass of the stand-forming tree species in the ecosystem was estimated by B. PAPP (1974), while that of the herbaceous layer by JAKUCS—PAPP (1974). In the present paper the results of the shrub-layer investigations are summarized.

Description of the forest

The description of the Síkfőkút forest, the detailed program of the complex biosphere research and the main research data have been furnished by JAKUCS (1973), while the results relating to structural conditions have been summarized by JAKUCS—HORVÁTH—KÁRÁSZ (1975). Therefore prior to our own research results, we mention here only those data which are most directly connected with the phytomass investigations of the shrubs.

The ecosystem studied is an about 65-year-old, climazonal, homogeneous turkey oak forest *(Quercetum petraeae-cerris)* in which the cover value of the free canopy is 80%. The quantity of through-fall radiation permits the development of photophyllous and thermophilous shrubs rich in species. The shrub layer, consisting of 16 species, can be subdivided into two distinct levels (low and high shrub levels). In our grouping, the high shrub level comprises shrubs

* Síkfőkút Project No. 21

of higher than 1 m height and of at least 1.2 cm stem diameter, while shrubs not possessing these characteristics are grouped into the low shrub level.

The dominant shrub species in the high shrub level are *Cornus mas*, *Acer campestre*, *Cornus sanguinea*, *Acer tataricum*, *Quercus petraea;* in the low shrub level: *Lingustrum vulgare*, *Euonymus verrucosus*, *Cornus sanguinea*, *Quercus petraea.*

Method

In every forest ecosystem there can be found shrubs whose dimensions (height, stem diameter, etc.) are average, that is, their dimension values are around the mean value determined on the basis of measuring several hundreds of individuals. The total weight of these shrubs of average dimensions, or that of their components (foliage, branch, stem, etc.), can also be considered average (OVINGTON—FORREST—ARMSTRONG 1968). Individuals can thus be selected from the stand the dimensions and weight of which are in all probability near the average of the total or partial size and weight relating to all of the individuals. It is this inference on which the "average-shrub" method, used in the estimation of the phytomass of the shrub layer in the Síkfőkút forest between August 29 and September 5, 1973, is based. This period of year is considered suitable for estimating because it is the last phase of the vegetation period when growth can be expected to be practically completed.

The estimation of the phytomass was carried out in a breakdown of species by shrub layers, thus the errors originating from the differences in weight data between dominant and suppressed shrubs could be reduced to a minimum. According to the data available from the literature, the accuracy of the estimations made with this method is between $\pm$ 7–10% (STATO 1966, OVINGTON et. al., 1968).

According to our measurements, the parameters most characterizing the dimensions of the shrub individuals are height, stem diameter (measured at 5 cm above ground level), and cover value. The parameters of the average shrubs were determined for 6 species *(Acer campestre, A. tataricum, Cornus mas, C. sanguinea, Ligustrum vulgare, Quercus petraea)* in the high shrub level, while in the low shrub level for 10 species (the same as in the high shrub level, and also *Crataegus monogyna, Euonymus europaeus, E. verrucosus, Rosa canina*), on the basis of measurements of 302 high shrub and of 561 low shrub specimens (50—60 individuals of each species). Height was measured with a 4 m long yardstick, while stem diameter with a sliding caliper 5 cm above ground. In high shrubs, the stem diameter was measured from two directions subtending a right angle and the average of the results of the two measurements was accepted as the stem diameter value. Cover values were read of the projection map of foliage closing in shrubs (KÁRÁSZ, 1973). In high shrubs, root removal was made in a circle of about 1 m radius to a depth of 60—70 cm, while in low shrubs within a circle of about 25—30 cm radius and to depth of 35—40 cm. Where the ramification of the roots made it necessary, we followed the pattern root positions.

Sampling

Shrubs of average dimensions were selected from both the high and the low shrub levels, 10 individuals of each species (sample shrubs), and these were cut out. Their roots together with the adhering soil were removed and then washed three times under running water through griddles used in soil examinations. The fresh foliage weight, stem + branch weight and root weight of all sample shrubs were weighted on a laboratory tare-balance in the field. At the same time the following samples were collected for the determination of leaf number and dry weight values:

500 leaves per sample shrub in the high shrub level, that is a total of 5000 leaves; and 100 leaves per sample shrub in the low shrub level, that is a total 1000 of leaves; in both of categories for each species;
mixed stem + branch samples (about 250 g stem and at least 3 kinds of branch samples with different widths, from each species);
root samples total root quantity as defined above.

The samples were dried to weight stability in an exsiccator at 85°C. After and before drying, the samples were weighed within an accuracy of 100th gram. (The first measurement was made at the time of removal in the field.) In the knowledge of the fresh weight of the fractions (leaf, stem + branch, root) and of the samples, we calculated the corresponding leaf number for the individual shrub as well as the dry weight per fraction, and also the total dry weight, by using the dry weight data. By multiplicating the weight data thus obtained by the serial number per hectare, the phytomass dry weight per hectare was estimated in a breakdown per species.

Let us note here that no detailed sampling of this character, related to shrubs, has been made in a turkey oakwood forest ecosystem so far. Similar elaborations with regard to other ecosystems have been reported in the works, for example, of DUDA—KOLEK (1970), DUVIGNEAUD (1971), DUVIGNEAUD—DENAEYER—AMBROES—TIMPERMAN (1971).

Results

The characteristic parameters (height, stem diameter, cover) of the average shrubs in comparison with the dimensions of the sample shrubs are given in Table 1. As is seen in the Table, the dimensions of the sample shrubs do not differ, or differ only to a minimum extent, from the dimensions of the average shrubs determined by measurements and calculations.

Results of the phytomass estimation in a breakdown per species are summarized in Table 2, where also the number of shrub stems per hectare, their leaf number, and the phytomass of the shrubs expressed in dry weight per hectare are given, in a breakdown per species and in total values. The leaf number of the shrubs per hectare is 12,157, 764; of this, 1,997, 488 leaves (16.42%) are in the low shrub level, while 10,160,276 leaves (83.58%) are in the high shrub level. In the formation of assimilating leaf surface, most leaves are carried by *Cornus mas* (5,643,902 leaves/hectare), and by *Acer campestre* (3,666,645 leaves/hectare). Further significant plants are: *Ligustrum vulgare* (809,312 leaves/ha), *Cornus sanguinea* (584,395 leaves/ha), and *Euonymus verrucosus* (504,500 leaves/ha) which occurs almost exclusively in the low shrub level.

The total phytomass of individuals of average dimension of the high shrub level species changes between 220 g and 1150 g. It is the highest *Acer campestre* (1151.82 g/specimen, followed by *Acer tataricum* (1095.75 g/specimen) and *cornus mas* (1070.82 g/specimen).The sequence is different concerning total dry weight per hectare. Similarly to the case of stem+branch phytomass, *Cornus mas* represents essentially greater quantities (2765.99 kg, which amounts to 40.63% of the total), and so does *Acer campestre* (2263.31 kg; 33.25%) than all the other species with a total phytomass of 1777.71 kg (26.12%) per hectare.

On one hectare area of the forest, there is a total of 6807.01 kg shrub phytomass. Of this, 757.34 kg (11.13% of the total phytomass) appears in the low shrub level, while 6049.67 kg (88.87%) in the high shrub level. Its distribu-

Acta Botanica Academiae Scientiarum Hungaricae 22, 1976

Table 1

Height, stem-diameter and cover data of the average shrubs and of the sample shrubs (l = low shrub, h = high shrub)

Name of shrub species	Height, m				Stem diameter, cm				Cover, m²			
	Average shrubs		Sample shrubs		Average shrubs		Sample shrubs		Average shrubs		Sample shrubs	
	l	h	l	h	l	h	l	h	l	h	l	h
Acer campestre	0.329	2.294	0.330	2.500	0.44	2.60	0.439	2.606	0.034	2.79	0.054	3.10
Acer tataricum	0.291	2.677	0.296	2.720	0.35	2.41	0.351	2.418	0.040	1.87	0.040	1.85
Cornus mas	0.422	2.359	0.452	2.410	0.51	2.45	0.511	2.444	0.190	2.45	0.190	2.93
Cornus sanguinea	0.434	2.031	0.429	2.332	0.308	1.34	0.302	1.345	0.043	0.73	0.043	0.75
Crataegus monogyna	0.437	—	0.437	—	0.75	—	0.751	—	0.035	—	0.035	—
Euonymus europaeus	0.175	—	0.175	—	0.203	—	0.203	—	0.0068	—	0.0068	—
Euonymus verrucosus	0.291	—	0.295	—	0.35	—	0.351	—	0.036	—	0.036	—
Ligustrum vulgare	0.409	1.560	0.435	1.673	0.31	1.25	0.318	1.272	0.031	0.93	0.031	0.92
Quercus petraea	0.227	1.920	0.228	1.920	0.38	2.20	0.382	2.202	0.033	1.18	0.0325	1.16
Rosa canina	0.668	—	0.669	—	0.39	—	0.387	—	0.012	—	0.011	—

Table 2

Number of stems and leaves, as well as phytomass of the shrub level per hectare, according to fractions and their total (l = low shrubs, m = high shrubs)

Name of shrub species	Number of stems/ha			Number of leaves/ha			Foliage weight, kg/ha		
	l	h	total	l	h	total	l	h	total
Acer campestre	5,699	1905	7,604	170,970	3,495,675	3,666,645	9.43	189 64	199.07
Acer tataricum	7,335	430	7,765	73,350	351,310	424,660	8.20	37.90	46.10
Cornus mas	,959	2335	3,294	79,597	5,564,305	5,643,902	2.60	182.68	185.28
Cornus sanguinea	13,676	690	14,366	232,495	351,900	584,395	11.99	17.80	29.79
Crataegus monogyna	1,654	—	1,654	67,814	—	67,814	3.05	—	3.05
Euonymus europaeus	7,782	—	7,782	38,910	—	38,910	2.33	—	2.33
Euonymus verrucosus	14,700	—	14,700	504,500	—	504,500	7.39	—	7.39
Ligustrum vulgare	21,059	256	21,315	673,888	135,424	809,312	12.97	2.60	15.57
Quercus petraea	10,963	382	11,345	65,777	248,682	314,459	6.30	30.15	36.45
Rosa canina	508	—	508	42,164	—	42,164	0.78	—	0.78
Other*	3,069	52	3,121	48,023	12,980	61,003	1.67	1.70	3.37
Total	87,404	6050	93,454	1,997,488	10,160,276	12,157,764	66.71	462.47	529.18

Name of shrub species	Stem + branch weight, kg/ha			Root, kg/ha			Total phytomass, kg/ha		
	l	h	total	l	h	total	l	h	total
Acer campestre	19.71	1291.40	1311.11	39.95	713.18	753.13	69.09	2194.22	2263.31
Acer tataricum	17.45	313.67	331.12	53.40	119.65	173.05	79.05	471.22	550.27
Cornus mas	10.74	1894.80	1905.54	3.06	672.11	657.17	16.40	2749.59	2765.99
Cornus sanguinea	24.07	122.60	146.67	77.68	41.97	119.65	113.74	182.37	296.11
Crataegus monogyna	20.25	—	20.25	5.79	—	5.79	29.09	—	29.09
Euonymus europaeus	7.35	—	7.35	19.14	—	19.14	28.82	—	28.82
Euonymus verrucosus	26.90	—	26.90	83.94	—	83.94	118.23	—	118.23
Ligustrum vulgare	40.43	30.66	71.09	138.36	23.79	162.15	191.76	57.05	248.81
Quercus petraea	23.68	155.89	179.57	53.61	184.22	237.83	83.59	370.26	453.85
Rosa canina	1.57	—	1.57	1.42	—	1.42	3.77	—	3.77
Other*	6.14	14.48	20.62	15.99	8.78	24.77	23.80	24.96	48.76
Total	198.29	3823.50	4021.79	492.34	1763.70	2256.04	757.34	6049.67	6807.01

* Estimated values

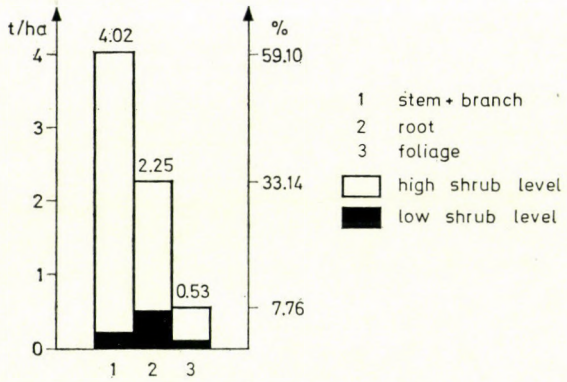


Fig. 1. Phytomass distribution of the shrubs according to fractions, per hectare, in t/ha and in percentage of the total

tion according to fractions is as follows: stem + branch represents 4021.79 kg (59.10%), roots 2256.04 kg (33.14%) foliage 529.18 kg (7.76%). The distribution according to fractions is shown in Fig 1.

REFERENCES

DUDA, M.—KOLEK, J. (1970): Vertical biomass distribution during vegetation in the dvoran variety of barley. Res. Project. Báb, Progr. Rep. Bratislava **1,** 111—114.

DUVIGNEAUD, P. M. (1971): Productivité des écosystèmes forestiers (Acte du colloque de Bruxelles organisé par l'Unesco et le Programme biologique international). UNESCO Paris, 646—649.

DUVIGNEAUD, P. M.—DENAEYER, S.—AMBROES, P.—TIMPERMAN, J. (1971): Recherches sur l'écosystème forest., 66—71.

JAKUCS, P. (1973): "Síkfőkút Project." Egy tölgyes ökoszisztéma környezetbiológiai kutatása a bioszféra program keretén belül (Síkfőkút Project. Environmental-biological research of the ecosystem of turkey-oak forest, within the framework of the biosphere program). MTA Biol. Oszt. Közl. **14,** 11—25.

JAKUCS, P.—PAPP, M. (1974): Production investigations of the undergrowth (herbaceous layer) of a Quercetum petraeae-cerris forest ecosystem. Acta Bot. Acad. Sci. Hung. **20,** 295—308.

JAKUCS, P.—HORVÁTH, E.—KÁRÁSZ, I. (1975): Contributions to the aboveground stand structure of an oak forest ecosystem (Quercetum petraeae-cerris) within the Síkfőkút research area. Acta Biol. Debrecina **12,** 149—153.

KÁRÁSZ, I. (1973): Vizsgálatok a "Síkfőkút Project" cseres-tölgyes ökoszisztéma "A" négyzete cserjefajainak struktúraviszonyain (Investigations of the structure conditions of the shrub species in the "A" plot of the turkey-oak wood ecosystem; "Síkfőkút Project"). Tud. Diákköri Dolg. (Scientific paper for a students' Group). Mscr.

OVINGTON, J. D.—FORREST, W. G.—ARMSTRONG, J. S. (1968): Tree biomass estimation. Symposium on primary productivity and mineral cycling in natural ecosystems (Young, H. E., ed.). Univ. Maine Press, Orono 4—31.

PAPP, B. L. (1974): Aboveground biomass of Quercus petraea and Quercus cerris in the research area at Síkfőkút. Acta Bot. Acad. Sci. Hung. **20,** 333—339.

SATOO, T. (1966): Production and distribution of dry matter in forest ecosystems. Misc. Inform. Tokyo Univ. Forests **16,** 1—15.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1—2), pp. 85—105 (1976)

DIE BEDEUTUNG DER BALATON-UFERZONE FÜR DEN UMWELTSCHUTZ AM SEE

Von

M. Kovács

BOTANISCHES FORSCHUNGSINSTITUT DER UNGARISCHEN AKADEMIE DER WISSENSCHAFTEN, VÁCRÁTÓT

(Eingegangen Juni 18, 1975)

Die Böden der Uferzone des Balaton sind dank den anaeroben Verhältnissen reich an organischen Substanzen und somit imstande, grosse Mengen biogener Elemente zu adsorbieren. Böden mit grosser Adsorptionskapazität entfalten eine Filterwirkung, die die Beschaffenheit des Seewassers günstig beeinflusst. Die Bebauung des Uferstreifens hat die Niedrighaltung des Wasserstandes unerlässlich gemacht, die Senkung des Wasserstandes aber führt zum Aufkommen aerober Verhältnisse und damit zur Mineralisierung der aufgespeicherten organischen Stoffe, wobei die freigesetzten biogenen Elemente — unter ihnen besonders der Stickstoff — den Nährstoffreichtum des Sees vermehren können.

Die bestandbildenden Pflanzen der Uferzone speichern in ihren Organismen grosse Mengen biogener Elemente, besonders Kalium, Stickstoff und Phosphor auf. Dank seinem Nährstoffanreicherungsvermögen »durchseiht« der Uferbewuchs einerseits die vom Ufer her kommenden Nährstoffe, während er andererseits die bereits ins Wasser gelangten Aufbaustoffe »ausfiltert«.

Seit einer Reihe von Jahren droht zunehmend die Gefahr der Vernichtung der natürlichen Uferzone des Sees. Trotz jedem Gegenargument der Experten und allen gesellschaftspolitischen Erwägungen wurde ein erheblicher Teil der Uferzone des Sees parzelliert und bebaut. Wie von Felföldy und Tóth (1970) treffend festgestellt, bildet die Bebauung des Uferstreifens ein »abschreckendes Beispiel einer vernunftwidrigen und das Leben des Sees völlig missachtenden Siedlungspolitik«.

Zufolge der menschlichen Eingriffe sind zahlreiche für den Balaton kennzeichnende Assoziationen verschwunden und wertvolle Biotope mit ihrer charakteristischen Fauna verkümmert.

Der niedrige Wasserstand des Balaton beeinflusst — wie dies von Hydrologen und Biologen vielfach betont wurde — die Bewirtschaftung des Seewasservorrates sowie seine chemischen und biologischen Verhältnisse. Bei dem niedrigen Wasserstand haben sich überreiche Algen- und Laichkrautmassen (Gelege) entwickelt, die Schilfzone ist von Land her in das Wasser vorgedrungen, d. h. die Nährstoffanreicherung und die Auffüllung des Sees bzw. sein Alterungsprozess haben sich beschleunigt.

Die Bedeutung der Uferzonation

Die Ufervegetation und ihr Biotop bilden einen organischen Teil des See-Ökosystems. Am Ufer des Balaton entlang erscheinen je nach den Feuchtigkeits- und Bodenverhältnissen in gürtelartiger Anordnung unterschiedliche Pflanzenarten. Hinter der Laichkrautzone bilden auf der eutrophen Gyttja bis zu einer Wassertiefe von 2,5 m *Schoenoplectus lacustris* und sodann *Phragmites communis* (bis 2 m Wassertiefe) und stellenweise *Typha angustifolia* ausgedehnte Bestände (vgl. Soó 1933, KÁRPÁTI—VARGA 1970). Auf ständig wasserüberdeckten, an organischen und an Nährstoffen reichen Standorten dominieren *Glyceria maxima* und *Phalaris arundinacea*. Auf den höher gelegenen Moorwiesen- und Wiesenböden sowie auf den zeitweilig von Wasser überdeckten Stellen befinden sich verschiedene *Magnocaricion*-Assoziationen *(Caricetum acutiformis, Caricetum gracilis)* sowie Sumpfwiesen (mit *Agrostion: Festucetum pratensis-, Juncus subnodulosus*-Bestände).

Die Wasser- und die Uferpflanzen haben eine ganz bestimmte biologische und ökologische Funktion: sie beeinflussen den Sauerstoffhaushalt des Wassers, die Kalk- und Kohlendioxydverhältnisse und die mineralischen Nährstoffe, auch sind sie an der Ausgestaltung der Verdunstungs- und Temperaturverhältnisse (JAKUCS—MAROSI—SZILÁRD 1971), an der Verlandung, am Material- sowie Energiehaushalt und schliesslich an der Selbstreinigung des Wassers beteiligt (BITTMANN 1968). Bekannt ist auch die Filterwirkung des Uferbewuchses (FELFÖLDY—TÓTH 1970, TÓTH 1970, 1972). Wo im Wasser vor dem Ufer der Schilfgürtel unversehrt steht, gelangen von Ufer her weniger eingeschwemmte Nährstoffe und verschiedene Schmutzstoffe in den See. Nach Untersuchungen am Velence-See war dessen Wasser, wo es keinen Schilfgürtel gab, an Nährstoffen reicher.

Die charakteristische Uferzonation hat sich in erster Linie am Nordufer des Balaton und in der Bucht von Keszthely herausgebildet, wo sie dem See den gleichen Schutz bietet, der ihm einst von dem Kisbalaton (der Kleine-Balaton) und dem unterschiedlichen Buschwerk am Südufer des Sees geboten wurde.

Der weitgehenden Ausrottung der Uferzonen, die in den letzten Jahren um sich gegriffen hat, ist die starke Nährstoffanreicherung am ganzen Balaton-Nordufer entlang zuzuschreiben. Sie tritt besonders dort in Erscheinung, wo der einst geschlossene Schilfbewuchs aufgelöst wurde; an diesen Stellen erscheint als biologischer Indikator der Nährstoffanreicherung *Stratiotes aloides* in grossen Massen (TÓTH 1974).

Eine äusserst ergiebige und ständig fliessende Gefahrenquelle stellen die landwirtschaftlich genutzten Gebiete (Erosion, Kunstdünger- und Pestizideauswaschungen, Viehhaltungsbetriebe usw.) dar. Nach Untersuchungen von NÉMETH und TÓTH (1974) in Jahre 1971 wurden in der Balaton-Gegend von 1 ha

landwirtschaftlich genutzter Fläche 199 kg Nährstoffe ausgewaschen, die zu 34% aus N, zu 24% aus P_2O_5 und zu 42% aus K_2O, d. h. aus Nährstoffen bestanden, die in der Nährstoffanreicherung der Gewässer eine sehr bedeutende Rolle spielen. Im Einzugsgebiet des Balaton ist von den landwirtschaftlich genutzten Flächen eine Stickstoffauswaschung von jährlich 2000—3000 t zu erwarten. In den rund 68 Viehhaltungsbetrieben und Ställen fallen jährlich schätzungsweise 800 000—900 000 m^3 Jauche an (OMFB 1974).

Die Bodenverhältnisse in der Uferzonation

Zur Erfassung der Boden- und Vegetationsverhältnisse in der Uferzone und zur Bestimmung der ökologischen und zönologischen Unterschiede bedienten wir uns der Transekt-Methode. Die Boden- und Pflanzenproben sammelten wir durch die verschiedenen Zonen (je nach der räumlichen Ausdehnung der Zonationen in Abständen von 1, 2 und 5 m an normal auf das Balatonufer verlegten, gedachten Geraden entlang. Aufgrund der Methodik von Ballenegger—Di Gléria (1962) bestimmten wir folgende Faktoren: die Wasserstoffionenkonzentration (pH), das $CaCO_3$%, den Gehalt an hygroskopischem Wasser (hy) und an Humus sowie die Humusstabilitätszahl (Q), den Gesamtgehalt an Stickstoff, Ammoniak und Nitraten, an Phosphor und an leicht aufnehmbarem Kalium, die adsorbierten Ca- und Mg-Mengen sowie schliesslich das potentielle Nitrifikationsvermögen der Böden.

Die chemische Zusammensetzung der Pflanzen bestimmten wir nach den Methoden von Paech—Tracey (1956) und Cooke (1969).

Die Untersuchungen erstreckten sich auf folgende Stichprobengebiete:

a) Die Mündung des Flusses Zala (Abb. 1), der an Nährstoffen reichste Teil des Balatonufers. An der Belastung des Balaton mit organischen Substanzen ist die Zala mit einem Anteil von 50% beteiligt, während sich die am Nordufer in den See ergiessenden Gewässer zur Belastung mit 20%, jene am Südufer hingegen mit einem Anteil von 30% beitragen. Mit Stickstoff belastet den See allein der Fluss Zala mit einem Anteil von 30—40% (die Gewässer der nördlichen Seite haben eine Belastung von 30—40%, jene der südlichen Seite eine solche von 20%.) Ähnlich hoch ist auch die Phosphor-Belastung der Zala (50% gegenüber der Belastung der Gewässer der nördlichen und südlichen Ufer mit je 25%). Der Gesamtstickstoffgehalt der Zala beträgt 2,18 mg, ihr Gesamtphosphorgehalt 0,68 mg jeweils je Liter (OMFB 1974). Stickstoff und Phosphor in solchen Mengen enthalten weder die fliessenden Gewässer der nördlichen, noch die der südlichen Seite.

b) Die Bucht von Szigliget (Abb. 2), wo der Gehalt des Seewassers an organischen Substanzen und seine Ionenkonzentration geringer, und die Uferzone auch dementsprechend weniger eutroph ist.

c) Die Halbinsel Tihany (der Uferabschnitt unter dem Csúcshegy).

Die Resultate der in Transekten durchgeführten Bodenuntersuchungen sind in den Abbildungen 3, 4 und 5 dargestellt. Zusammenfassend kann festgestellt werden:

Unter der Einwirkung von Wasser, Boden und Vegetation ändern sich auch die quantitativen Verhältnisse der Bodenfaktoren. Bei der Ausgestaltung der Bodenfaktoren aber spielen die Feuchtigkeitsverhältnisse eine ausschlaggebende Rolle.

Als Folge der starken Vermehrung in der Produktion der bestandbildenden Pflanzen der Uferzone (*Schoenoplectus lacustris*, *Typha angustifolia*, *Phrag-*

Abb. 1. Die Mündung des Zala-Flusses in der Bucht von Keszthely. Luftbildaufnahme der Wasserwirtschaftsdirektion Pécs

mites communis, *Glyceria maxima*, *Phalaris arundinacea*, verschiedene *Carex* Arten usw.) gelangen alljährlich grosse Mengen organischer Stoffe in das Seewasser bzw. auf die Bodenoberfläche. Die Böden der Schilfrohr- und Riedgrasassoziationen sind während eines Grossteils des Jahres überschwemmt, bzw. mit Wasser völlig durchtränkt. Die anaeroben Verhältnisse führen zur Anhäufung von erheblichen Mengen organischer Substanzen. Der Gehalt des Bodens an diesen liegt für gewöhnlich über 10%. In der Mündung der Zala, wo der Boden ausser der Produktion von *Phragmites communis*, *Glyceria maxima* und *Phalaris arundinacea* zusätzlich auch noch von den vom Fluss herangetragenen organischen Substanzen belastet wird, erreicht die Menge der angereicherten organischen Substanzen Anteile von 30—40%. Mit den

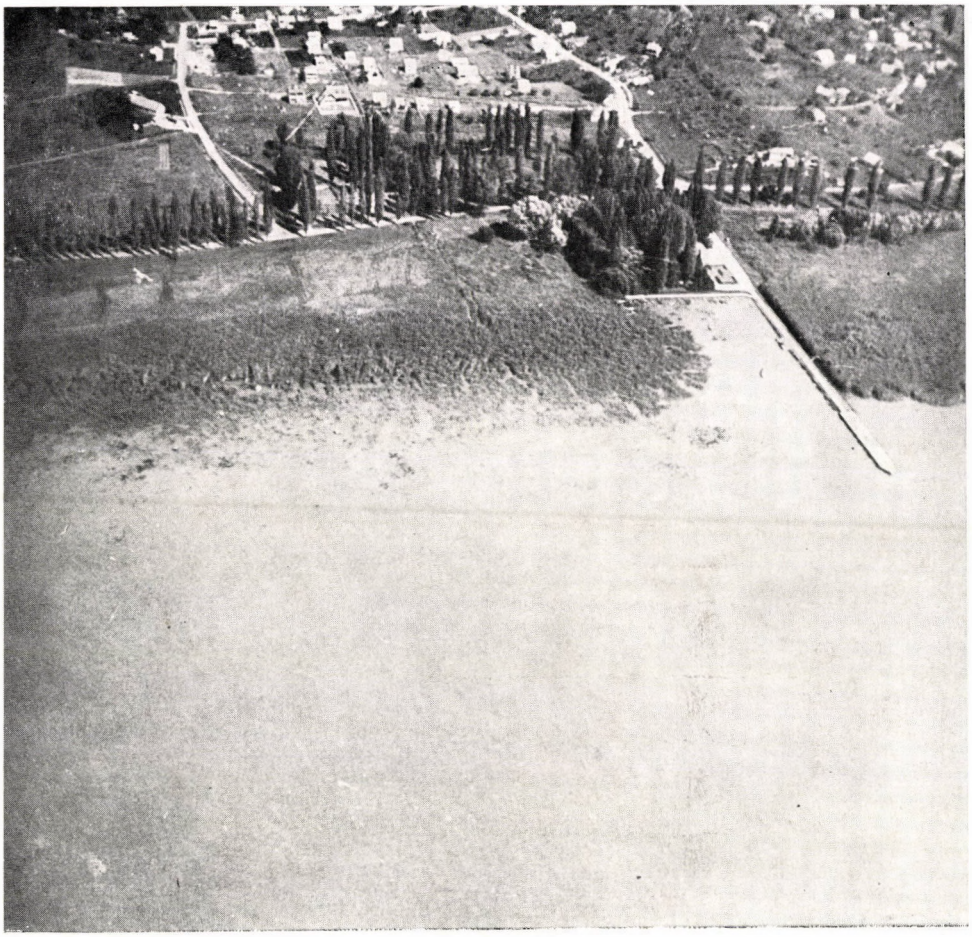


Abb. 2. Dem Schutz des See-Ökosystems dient der Schilfrohrgürtel vor dem Ufer der Bucht von Szigliget. Luftbildaufnahme der Wasserwirtschaftsdirektion Pécs

angehäuften organischen Stoffen schalten die Ökosysteme der Uferzone aus dem biogeochemischen Zyklus für eine bestimmte Zeitdauer eine grössere Zahl von Elementen aus. Zwischen dem Gehalt der Böden an organischen Substanzen und ihrem Gesamtstickstoffgehalt besteht eine positive Korrelation (Abb. 6). An der Mündung der Zala liegt der Gesamtstickstoffgehalt der Böden bei 0,7—1,3%. Die dauernde Überdeckung mit Wasser bzw. die anaeroben Verhältnisse verhindern zwar die Mineralisierung von grossen Mengen organischen Substanzen beim Absinken des Wasserspiegels sind sie jedoch als potentielle Gefahrenquellen anwesend (vgl. weiter unten).

Böden mit hohem Gehalt an organischen Substanzen haben eine grosse Adsorptionskapazität und Filterwirkung. (Nach den Untersuchungen von

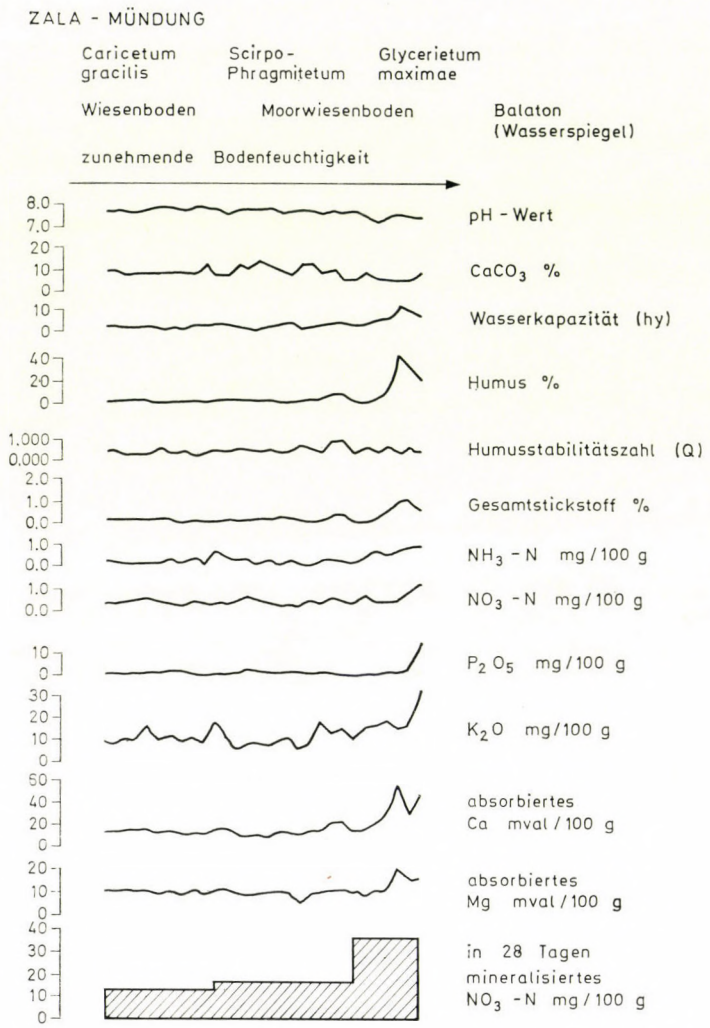


Abb. 3. Die Änderung der Bodenfaktoren im Untersuchungsflächentransekt an der Zala-Mündung

Bailey und White — 1964 — haben die Pestizide in den Böden mit hohem Gehalt an organischen Substanzen die geringste toxische Wirkung.)

Ab leicht aufnehmbarem Kalium enthalten die Wiesenböden *(Festucetum pratensis)* der höher gelegenen Zone 5—10 mg/100 g, die Moorwiesenböden des unmittelbar am Wasser gelegenen Uferstreifens 10—30 mg/100 g.

Die kaliumreichen (Tabelle 1) beständebildenden Pflanzen der wassernahen Uferzone bleiben in der Regel an ihrem Standort stehen, so dass das im Pflanzenorganismus angereicherte Kalium nicht aus dem lokalen biogeo-

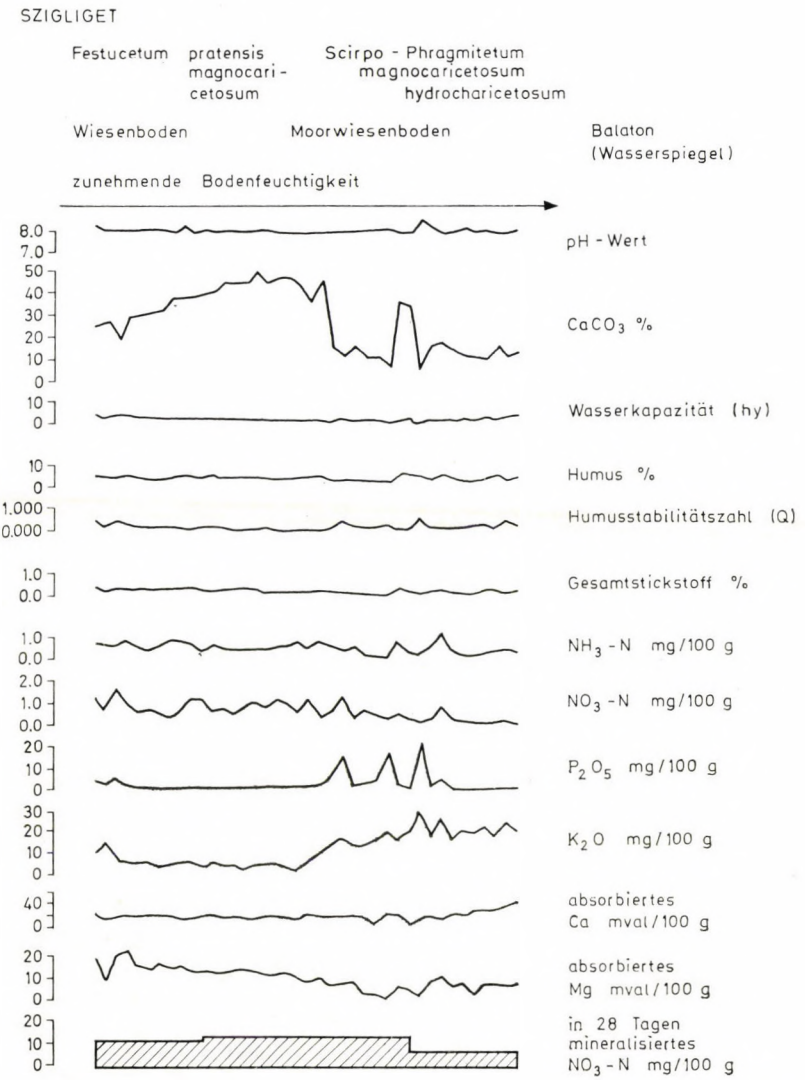


Abb. 4. Die Änderung der Bodenfaktoren im Untersuchungsflächentransekt bei Szigliget

chemischen Zyklus hinausgerät. Demgegenüber werden die Sumpfwiesen der räumlich höher gelegenen Zonen (z.B. mit *Festucetum pratensis*) Jahr für Jahr regelmässig gemäht, womit erhebliche Mengen des in die Pflanzen eingebauten Kaliums aus dem lokalen Kreislauf ausscheiden, wie dies die Änderung des Gehalts des Uferzonenbodens an leicht aufnehmbarem Kalium bzw. die stufenweise Zunahme des Kaliumgehalts in der Richtung des wassernahen Uferstreifens deutlich beweisen.

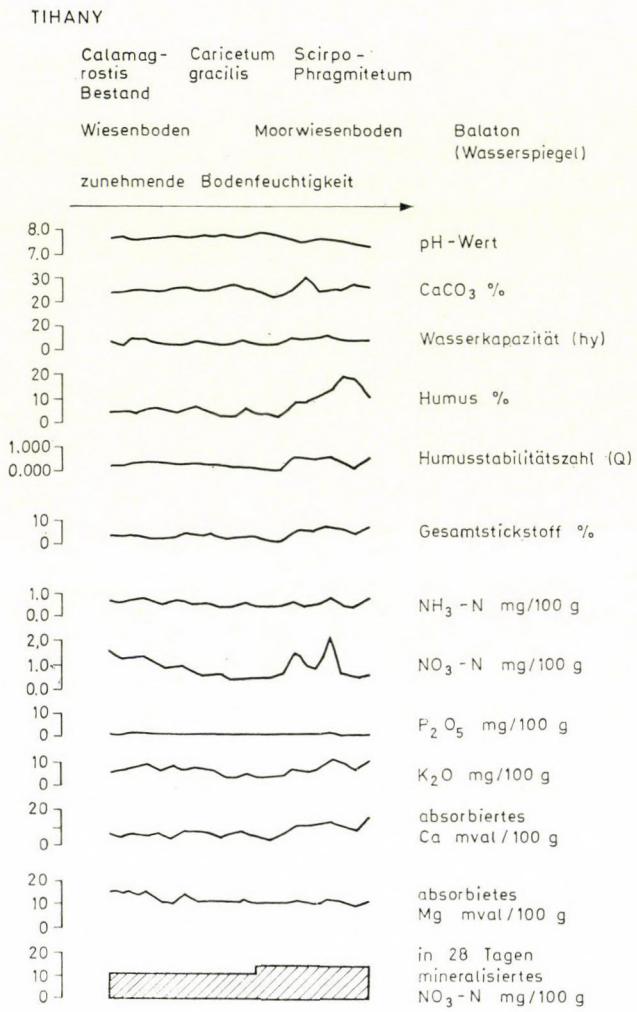


Abb. 5. Die Änderung der Bodenfaktoren im Untersuchungsflächentransekt bei Tihany

An der Erhöhung des Nährstoffgehaltes der Gewässer und an der Vermehrung der Wasserpflanzen ist neben dem Phosphor-, Stickstoff- und Kohlendioxydgehalt in erheblichem Masse auch das Kalium beteiligt (DIETRICH 1973).

Im Moorwiesenboden des Uferstreifens findet sich im allgemeinen auch eine grössere Phosphoranreicherung. In besonders grossen Mengen ist P_2O_5 in den Böden um die Mündung der Zala anzutreffen (14 mg/100 g), was in erheblichem Umfang auch auf die Phosphor-Belastung der Zala zurückzuführen ist.

Aufgrund der Bodenuntersuchungen in der Uferzonation kann zusammenfassend festgehalten werden: nach den tieferen Lagen und nach dem Wasser-

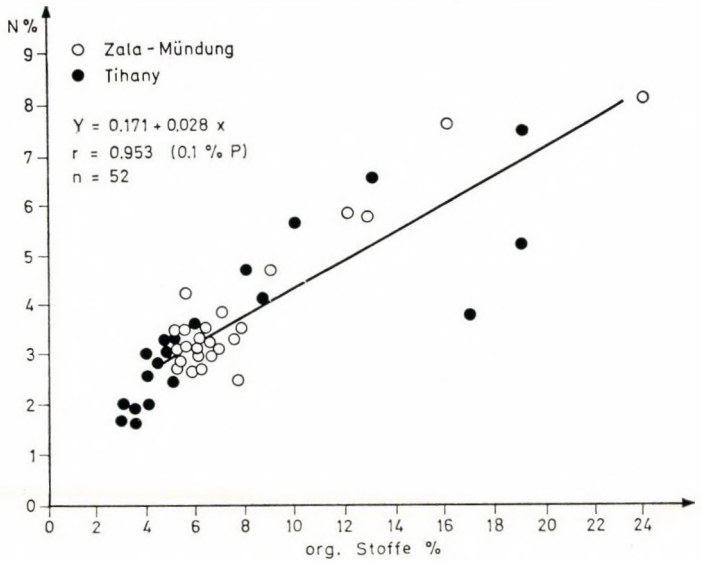


Abb. 6. Der Zusammenhang zwischen dem Gehalt der Böden an organischen Stoffen und ihrem Gesamtstickstoffgehalt

spiegel des Sees hin wächst parallel zur Zunahme des Gehalts an organischen Substanzen die Wasserhaltefähigkeit (Wasserkapazität) des Bodens, seine Adsorbtionskapazität sowie sein Gehalt an adsorbierten Kationen und an Stickstoff, Phosphor und Kalium.

Die Dynamik der Nitrifikation in den Böden der Uferzonation

Die Dynamik der Mineralisation (Nitrifikation) in den Böden der Uferzone untersuchten wir unter Laboratoriumsverhältnissen.

Die bis zu 60% ihrer Wasserkapazität durchfeuchteten Bodenproben liessen wir im Thermostat unter sterilen Verhältnissen 28 bzw. 35 Tage lang reifen.

Die Böden des sich unmittelbar am Wasser entlang hinziehenden Uferstreifens sind durch eine gute Nitrifikationsdynamik gekennzeichnet. Auf den *Phragmites*-Böden mineralisierten sich in 35 Tagen 10—15 mg/100 g, in den *Carex*-Böden hingegen 13—19 mg/100 g NO_3—N (Tabelle 2).

Besonders reich an Nitraten waren die Böden der *Glyceria maxima*-Bestände im Mündungsgebiet der Zala (36 mg/100 g. S. Abb. 3,54 mg/100 g. vgl. Tabelle 2, Probe 8).

Mit dem Rückgang des Gehalts an organischen Stoffen sinkt die Adsorbtionskapazität bzw. die Filterwirkung der Böden.

Tabelle 1

Chemische Zusammensetzung der aus den

Lfd. Nr	Name der Pflanze	Sammelstelle	Asche %	Ca %
1.	*Glyceria maxima*	Zala-Mündung	10,4	0,18
2.	*Glyceria maxima*	Zala-Mündung	10,4	0,19
3.	*Phragmites communis*	Zala-Mündung	9,8	0,19
4.	*Phragmites communis*	Zala-Mündung	9,7	0,23
5.	*Phalaris arundinacea*	Zala-Mündung	10,2	0,14
6.	*Phalaris arundinacea*	Zala-Mündung	9,2	0,12
7.	*Carex gracilis*	Zala-Mündung	8,1	0,19
8.	*Phragmites communis*	Szigliget	9,9	0,30
9.	*Phragmites communis*	Szigliget	8,2	0,20
10.	*Carex gracilis*	Szigliget	8,3	0,15
11.	*Carex gracilis*	Szigliget	8,6	0,16
12.	*Festuca pratensis*	Szigliget	10,8	0,33
13.	*Festuca pratensis*	Szigliget	11,8	0,26
14.	*Phragmites communis*	Tihany	11,8	0,10
15.	*Carex gracilis*	Tihany	8,3	0,20
16.	*Carex gracilis*	Tihany	8,3	0,18
17.	*Calamagrostis arundinacea*	Tihany	7,3	0,06
18.	*Calamagrostis arundinacea*	Tihany	7,4	0,06

Tabelle 2

Die nach 28- und 35tägiger Inkubation in den Böden der Uferzonation mineralisierten NH_3-N und NO_3-N-Mengen

Lfd. Nr.	Name der Pflanzengesellschaft	Sammelstelle	Der ursprüngl. Gehalt des Bodens an		In 28 Tagen mineralisierte Mengen von		In 35 Tagen mineralisierte Mengen von	
			NH_3-N	NO_3-N	NH_3-N	NO_3-N	NH_3-N	NO_3-N
			mg/200 g		mg/100 g			
1.	*Scirpo-Phragmitetum*	B.fűzfő	0,8	0,3	3,6	1,8	Spuren	10,0
2.	*Scirpo-Phragmitetum*	B.almádi	0,9	0,3	1,1	10,6	0,6	11,4
3.	*Scirpo-Phragmitetum*	Tihany	0,9	0,3	0,5	15,1	0,4	16,1
4.	*Scirpo-Phragmitetum*	B.udvari	0,9	0,3	0,1	14,6	Spuren	15,8
5.	*Caricetum gracilis*	Ábrahámhegy	0,8	0,5	2,6	14,6	0,6	19,6
6.	*Caricetum gracilis*	Badacsony	0,8	0,5	0,2	10,3	Spuren	13,5
7.	*Caricetum gracilis*	Gyenesdiás	0,6	1,7	2,0	10,7	0,3	13,4
8.	*Glycerietum maximae*	Fenékpuszta	1,2	0,3	0,2	49,0	0,1	54,0

Transekten stammenden Pflanzenarten

K %	Na %	Mg %	P_2O_5 %	N %	Mn ppm	Fe ppm	Zn ppm
2,18	0,03	0,34	0,82	1,99	252	128	20
2,21	0,03	0,36	0,84	1,87	173	168	25
1,65	0,01	0,31	0,69	4,13	466	121	32
1,31	0,01	0,47	0,63	3,95	488	171	24
1,42	0,01	0,28	0,38	2,33	97	114	21
1,66	0,01	0,29	0,46	2,37	61	150	22
1,67	0,01	0,34	0,45	1,90	217	203	16
1,03	0,02	0,43	0,37	2,46	113	99	33
1,37	0,01	0,29	0,46	2,85	241	94	18
1,20	0,02	0,29	0,29	1,31	184	137	15
1,18	0,02	0,22	0,24	1,36	171	116	15
0,39	0,06	0,46	0,24	1,06	54	164	11
0,46	0,07	0,46	0,23	1,11	56	141	18
1,20	0,02	0,20	0,36	2,97	174	98	38
1,27	0,01	0,30	0,20	1,31	178	96	20
1,26	0,02	0,29	0,20	1,36	155	101	15
1,05	0,01	0,19	0,19	0,99	59	87	30
0,98	0,01	0,18	0,17	0,82	48	58	24

Die Filterwirkund des Bodens ist für den Schutz des Sees von grösster Bedeutung. Die Nähr- und ein Teil der Schmutzstoffe werden dem See durch das strömende Grundwasser zugeführt. Nach Untersuchungen des Wissenschaftlichen Forschungsintituts für Wasserwirtschaft strömt das Grundwasser den See zu; durch diese Strömung gelangen jährlich 168 000 m^3 Grundwasser in den See.

Zusammenfassend darf festgestellt werden, dass die Böden des unmittelbar am See gelegenen Uferstreifens in grossen Mengen organische Substanzen und Stickstoff enthalten. Im natürlichen Zustand, d. h. unter anaeroben Verhältnissen geht der Abbau der organischen Substanzen langsam vor sich, und ebenso ist die Dynamik der Nitrifikation schwach. Der aktuelle Nitratgehalt der Böden liegt bei 0,3—4,0 mg/100 g.

Durch die Lockerung der Uferzonenböden, durch Konstanthaltung des niedrigen Seewasserstandes und durch die zunehmende Durchlüftung beschleunigt sich die Zersetzung der Reserven des Bodens an organischen Substanzen und die Dynamik der Mineralisation (vgl. ZIMENKO 1972), d. h. es

Tabelle 3

Chemische Zusammensetzung einzelner

Lfd. Nr.	Name der Pflanze	Sammelstelle	Asche %	Ca %
1.	*Phragmites communis*	B.fűzfő	12,8	0,30
2.	*Phragmites communis*	B.almádi	10,3	0,29
3.	*Phragmites communis*	Tihany	14,0	0,31
4.	*Phragmites communis*	B.udvari	12,6	0,51
5.	*Phragmites communis*	Ábrahámhegy	11,6	0,54
6.	*Phragmites communis*	Badacsony	11,3	0,31
7.	*Phragmites communis*	Gyenesdiás	11,9	0,37
8.	*Schoenoplectus lacustris*	Fenékpuszta	13,0	0,28
9.	*Typha angustifolia*	B.udvari	5,6	0,51
10.	*Typha angustifolia*	Badacsony	7,3	0,39
11.	*Typha angustifolia*	Fenékpuszta	6,7	0,25
12.	*Sparganium erectum*	Badacsony	13,5	0,89
13.	*Carex riparia*	Tihany	9,1	0,18
14.	*Carex gracilis*	Gyenesdiás	8,8	0,45
15.	*Carex acutiformis*	B.almádi	9,8	0,38
16.	*Carex acutiformis*	Badacsony	8,4	0,44
17.	*Carex acutiformis*	Badacsony	8,2	0,29
18.	*Juncus subnodulosus*	Ábrahámhegy	11,9	0,32
19.	*Agrostis alba*	Fenékpuszta	12,3	0,13
20.	*Glyceria maxima*	Fenékpuszta	8,8	0,15

muss mit der potentiellen Gefahr gerechnet werden, dass Stickstoff in grossen Mengen in den See gelangt.

Die chemische Zusammensetzung der bestandbildenden Pflanzen der Uferzone

Neben der Filterwirkung des an organischen Substanzen reichen Bodens macht sich zusätzlich auch die »Filter-Wirkung« der Pflanzen der Zonation geltend.

Die chemische Untersuchung des Pflanzenmaterials, das von mehreren Punkten der nördlichen Uferlinie des Balaton (Tabelle 3), ferner aus den Transekten der Zala-Mündung und aus jenen von Szigliget und Tihany (Tabelle 1) eingesammelt worden war, sollte die Frage klären, inwieweit der Nährstoffgehalt des Bodens die Anreicherung biogener Elemente in den einzelnen Pflanzenarten bestimmt.

Pflanzenarten der Uferzonation

K %	Na %	Mg %	P_2O_5 %	N %	Mn ppm	Fe ppm	Zn ppm
0,81	0,03	0,38	0,20	1,95	233	63	32
0,41	0,04	0,30	0,20	1,56	85	58	35
0,54	0,03	0,40	0,16	1,58	131	63	35
0,50	0,04	0,31	0,14	1,36	114	55	26
0,54	0,03	0,31	0,13	1,24	237	55	23
0,45	0,02	0,43	0,17	1,55	159	70	38
0,34	0,03	0,38	0,14	1,52	114	55	16
3,71	0,06	0,39	0,22	1,97	234	78	16
0,85	0,27	0,39	0,19	1,52	346	55	46
1,03	0,57	1,22	0,26	2,15	1417	42	122
1,94	0,16	0,48	0,29	2,78	342	121	33
2,12	0,59	0,93	0,26	2,11	97	86	15
0,86	0,01	0,33	0,16	1,41	98	61	4
0,85	0,02	0,44	0,13	1,13	240	71	43
1,03	0,01	0,42	0,18	1,46	150	105	13
0,44	0,03	0,43	0,18	1,87	230	100	26
0,85	0,04	0,89	0,23	1,41	237	63	13
2,03	0,36	0,43	0,21	1,69	398	84	38
1,60	0,03	0,38	0,28	2,04	115	105	19
2 24	0,02	0,38	0,24	2,39	72	85	26

Im Wasser der Zala konnte neben grossen Mengen organischer Substanzen auch eine bedeutende Gesamt-Ionenkonzentration festgestellt werden. In besonders grossen Mengen führt es Ca und Mg. In dem an organischen Substanzen reichen Boden der Zala-Mündung finden sich absorbiertes Ca (mit 80—100 mval/100 g) und Mg (mit 10—20 mval/100 g) in grösseren Mengen, wogegen sich stärkere Ca-und Mg-Anreicherungen in den Pflanzen eindeutig nicht nachweisen lassen (Tabelle 1).

Auf allen drei Transekt-Probeflächen enthält *Phragmites communis* mit 1,0—1,65% mehr K als beispielsweise die auf den höher gelegenen Wiesenböden vorkommenden *Calamagrostis arundinacea* (0,9—1,0%) oder *Festuca pratensis* (0,3—0,4%).

Bei regelmässigem Mähen der höher gelegenen Sumpfwiesen mit anschliessendem Fortschaffen der Mahd sinkt der Gehalt des Bodens an leicht aufnehmbarem Kalium.

Das gemeine Schilfrohr *(Phragmites communis)* vermag in seinem Organismus neben Kalium auch Phosphor und Stickstoff in grösseren Mengen auf-

Tabelle 4

Der Gehalt von Unterwasserpflanzen

Lfd. Nr.	Name der Pflanze	Sammelstelle	Asche %	Ca %
1.	*Ceratophyllum submersum*	Tihany	26,9	2,03
2.	*Ceratophyllum submersum*	Badacsony	23,2	0,68
3.	*Elodea canadensis*	Tihany	27,5	2,57
4.	*Hydrocharis morsus-ranae*	Tihany	32,4	2,72
5.	*Hydrocharis morsus-ranae*	Badacsony	30,9	0,70
6.	*Myriophyllum spicatum*	Tihany	27,1	2,84
7.	*Stratiotes aloides*	Tihany	34,8	5,06
8.	*Stratiotes aloides*	B.udvari	35,2	5,47
9.	*Utricularia vulgaris*	Tihany	31,7	3,78
10.	*Utricularia vulgaris*	Badacsony	27,9	3,08

zunehmen (Tabellen 1 und 3). Diese beiden Elemente reichern sich im Schilf besonders dort in grösseren Mengen an, wo sie auch in Boden stärker vertreten sind. *Phragmites communis* aus der Zala-Mündung z.B. enthält 0,63—0,69% P_2O_5 und 3,9—4,1% N.

In grösseren Mengen enthalten Phosphor und Stickstoff *Glyceria maxima* (s. Tabelle 1, Proben 1—2 und Tabelle 3, Probe 20), sowie *Typha angustifolia* (Tabelle 3, Proben 9—11).

Unter den Pflanzen der Uferzone reichern vorzugsweise *Glyceria maxima*, *Phragmites communis*, *Schoenoplectus lacustris* und *Typha angustifolia* Stickstoff, Phosphor und Kalium an, d. h. jene Elemente, die bei der Erhöhung des Nährstoffgehaltes des Wassers eine Rolle spielen.

Aus der Literatur ist das Elemente-Anreicherungsvermögen von *Schoenoplectus lacustris* bekannt (SEIDEL 1966, 1967).

Relativ viel Na enthalten *Sparganium erectum*, *Typha angustifolia* und *Juncus subnodulosus* (Tabelle 3). Bekannt ist auch das Kaliumanreicherungsvermögen von *Juncus subnodulosus* (KOVÁCS 1974).

Von den Spurenelementen kommt Mn in verhältnismässig grösseren Mengen vor. Nach den Transekt-Untersuchungen findet sich Mn besonders in den Pflanzen der wassernahen Uferzone und der während eines Grossteils des Jahres wasserüberdeckten Flächen, so in *Phragmites communis* (113—488 ppm), in der *Glyceria maxima* (173—252 ppm) und in *Carex gracilis* (155—217 ppm) (Tabelle 1). Einen höheren Mn-Gehalt können weiterhin *Juncus subnodulosus*, *Carex acutiformis* und *Typha angustifolia* aufweisen (Tabelle 3).

Auffallend viel (1417 ppm) Mn enthält *Typha angustifolia* in der Uferzone bei Badacsony. Wahrscheinlich besitzt *Typha angustifolia* in den an Mn reichen Gewässern bzw. auf den Mn-reichen Sedimenten ein starkes selek-

an mineralischen Stoffen

K %	Na %	Mg %	P_2O_5 %	N %	Mn ppm	Fe ppm	Zn ppm
2,21	0,43	1,56	0,28	2,22	1065	959	67
4,96	0,53	1,57	0,38	2,95	1137	1219	236
2,10	0,44	0,66	0,29	2,88	260	565	31
3,84	0,83	1,92	0,23	2,25	215	1702	71
2,15	0,41	1,18	0,33	3,24	394	1485	183
1,65	0,10	1,07	0,26	1,90	229	1213	36
5,42	0,77	1,91	0,29	1,83	374	587	46
4,36	0,55	2,00	0,16	1,13	243	319	42
3,41	0,71	2,20	0,42	—	719	2781	16
2,24	0,82	1,22	0,63	—	1417	1459	236

tives Vermögen zur Anreicherung von Mn-Kationen. Die Pflanze enthält übrigens auf dem Gebiet des Badacsony auch relativ viel Zn (122 ppm).

Kraft ihres grossen Nährstoffanreicherungsvermögens »filtert« die Ufervegetation einerseits die vom Land her dem See zuströmenden Nährstoffe, während sie andererseits die bereits in das Wasser gelangten Nährstoffe »ausfiltert«.

Gehen jedoch die Uferzone in ihrem natürlichen Zustand und deren Vegetation zugrunde, gelangen die Nährstoffe mangels »Aufnehmer« ungehindert in das Seewasser und verbleiben ebenso ungestört in diesem.

Es erscheint also geraten, die natürliche Pflanzendecke der Uferzone zu schützen und die Rohr-, Binsengras- und Schilfbestände an den Ufern entlang zu erhalten, und dies besonders dort, wo die Uferzonen an Nährstoffen reich sind, oder in der Nähe von Einmündungen fliessender Gewässer (wie etwa die Zala-Mündung), die das Wasser des Balaton mit grossen Mengen organischer Substanzen und Nährstoffe belasten.

Bleiben die grosse Massen liefernden und grosse Mengen biogener Elemente anreichernden Pflanzen des Uferzonengürtels an ihrer Stelle, dann gelangen die biogenen Elemente bei der Zersetzung der pflanzlichen Organismen in die Böden (Verlandungen) oder in das Seewasser zurück, wo sie eine weitere Nährstoffanreicherung verursachen können, weshalb es sich empfiehlt bzw. erforderlich ist, die Gelege des Ufergürtels regelmässig zu mähen und die Mahd zu entfernen.

Zu Vergleichszwecken und zur Beantwortung der Frage, wieviele Bioelemente den Pflanzen des Uferzonengärtels gegenüber die einzelnen Laichkrautarten in ihren Organismen einzubauen vermögen, bestimmten wir die chemische Zusammensetzung einiger Laichkrautarten (Tabelle 4).

Nach den Ergebnissen unserer eigenen Untersuchungen und nach Literaturangaben (HARPER—DANIEL 1939, TÓTH 1962, BOJCENKO—UDELNOWA 1964, BOJCENKO—SAENKO—UDELNOWA 1968 cit. in STUGREN 1967, WAGNER 1966, TÖLGYESI 1969 usw.) reichern die verschiedenen Laichkräuter von Ca, K, Na und Mg das Mehrfache jener Mengen an, die die beständebildenden Pflanzen der Uferzone aufnehmen. In besonders grossen Mengen reichert mineralische Elemente die am Nordufer entlang infolge der zunehmenden Nährstoffanreicherung in starker Verbreitung begriffene Art *Stratiotes aloides* an. N und P, die den Prozess der Nährstoffanreicherung fördern, kommen in anderthalb- bis zweimal so grossen Mengen vor wie in den Pflanzen des Uferstreifens.

Unter den Spurenelementen ist es wieder das Mn, welches in den Laichkräutern in relativ grösseren Mengen anzutreffen ist als in den Pflanzen der Uferzone. Durch ihr selektives Kationenanreicherungsvermögen ragen besonders *Ceratophyllum submersum* (1065—1137 ppm) und *Utricularia vulgaris* (719—1417 ppm) hervor. Auch viel Eisen reichern einzelne Laichkräuterarten an, so *Ceratophyllum submersum* (959—1219 ppm), *Hydrocharis morsus ranae* (1485—1702 ppm), *Myriophyllum spicatum* (1213 ppm) und *Utricularia vulgaris* (1459—2781 ppm). Die Untersuchung von Laichkräutern aus den Gewässern unweit des Badacsony ergaben, dass sie das Mehrfache jener Zinkmengen enthalten, die in Proben derselben Arten von anderen Punkten des Balaton anzutreffen sind.

Nach Literaturangaben (PINKOLA—TÓTH 1971) können sich in Laichkräutern des Balaton auch verschiedene Pestizide anreichern.

Wie die Untersuchung gezeigt hat, entziehen die Laichkräuter dem Seewasser für je eine bestimmte Vegetationsperiode grosse Mengen verschiedener biogener Elemente und bauen sie in ihre Organismen ein.

Der relative »Nährstoffmangel«, der sich im Seewasser infolge der Aufnahme grösserer Nächrstoffmengen durch die Laichkräuter einstellt, verhindert die stärkere Vermehrung der Algen (GESSNER 1939, MACKENTHUN 1962, MULLIGAN—BARANOWSKI 1969, TÓTH 1969, TÓTH—TÖLG—KONTUR 1969).

Die Dekomposition der Pflanzen, das Freiwerden der biogenen Elemente unter Laborverhältnissen

Für die Verhältnisse im Seewasser des Balaton ist es von Bedeutung, innerhalb welcher Zeit und in welchem Umfang sich die an Ort und Stelle verbleibenden abgestorbenen Pflanzen, die pflanzlichen organischen Stoffe mineralisieren und wie rasch und in welchem Umfang die verschiedenen Elemente frei werden.

Die Untersuchung der Dekomposition wurde an 5 Arten *(Phragmites communis, Glyceria maxima, Phalaris arundinacea, Carex gracilis, Festuca pratensis)* aus den Transekten an der Zala-Mündung, bei Szigliget und Tihany (Tabelle 1) nach dem Verfahren von JENNY—GESSEL—BINGHAM (1949) bzw. RAPP (1967, 1971) unter Laboratoriumsverhältnissen vorgenommen. Die Dekompositionsuntersuchungen erstreckten sich über einen Zeitraum von 20 Monaten (3. Okt. 1973—31. Mai 1975), wobei die mineralisierten Elemente (Ca, K, Mg, N, P_2O_5, Mn, Zn, Fe) monatlich quantitativ bestimmt wurden. Die Schaffung günstiger Voraussetzungen für die Zersetzungprozesse beschleunigt die Dynamik der Mineralisierung und gestattet Rückschlüsse auf die in der Natur sich abspielenden Vorgänge.

Die Untersuchungsergebnisse

a) *Gewichtsverlust:*

Der Vergleich der Probengewichte (25 g) vor der Dekomposition mit den nach 20 Monaten festgestellten Gewichten ergaben bei den verschiedenen Pflanzenarten folgende durchschnittliche Gewichtsverluste:

Glyceria maxima	65%
Phragmites communis	60%
Phalaria arundinacea	55%
Carex gracilis	53%

Laut der Untersuchungen waren mehr als 50% der Pflanzen in 20 Monaten dekomponiert. Am schnellsten zersetzen sich die Pflanzen von den unmittelbar am Wasser gelegenen Uferzonen, jene Arten also, die die meisten biogenen Elemente enthalten (vgl. Tabelle 1). Die aus dem Transekt der Zala-Mündung stammende, an biogenen Elementen reiche Art *Phragmites communis* (Tabelle 1, Proben 3 und 4) erlitt in 20 Monaten einen Gewichtsverlust von 77%, während dieser bei den weniger biogene Elemente enthaltenden Schilf-Proben von Szigliget und Tihany bloss 54—58% betrug.

b) *Der globale Verlust an Elementen und die Zersetzungsgeschwindigkeit*

Die Bestimmung der biogenen Elemente in den Pflanzen vor deren Dekomposition, ferner der monatlich mobilisierten Mengen und schliesslich der chemischen Zusammensetzung der nach 20 Monaten verbliebenen Pflanzensubstanz ergab für die einzelnen biogenen Makroelemente folgende Ge-

wichtsverluste (in %):

	Ca	K	Mg	N	P_2O_5
Phragmites communis	35	100	27	72	41
Glyceria maxima	54	100	35	66	35
Phalaris arundinacea	59	100	61	52	51
Carex gracilis	49	100	38	40	56
Festuca pratensis	42	100	81	30	62

Am schnellsten wurde Kalium frei; nach dem Verlauf von 12 Monaten wurde bei jeder Art 100% des in den Proben befindlichen Kaliums mobilisiert.

Hier muss natürlich in Betracht gezogen werden, dass die Pflanzen der Uferzone relativ viel K, N und P enthalten, die 41%ige Phosphorerschliessung bei *Phragmites communis* bedeutet also in absoluten Zahlen (54 mg) mehr als der 62% bei *Festuca pratensis* (37 mg).

Die Geschwindigkeit des Freiwerdens der Elementen bei den einzelnen Arten zeigt folgendes Bild:

Phragmites communis	K > N > P > Ca > Mg
Glyceria maxima	K > P > Ca > N > Mg
Phalaris arundinacea	K > N > Mg > Ca > P
Carex gracilis	K > P > Ca > N > Mg
Festuca pratensis	K > Mg > P > Ca > N

Nach der Zersetzungsgeschwindigkeit werden bei den bestandbildenden Pflanzen der Uferzonation *(Phragmites communis, Glyceria maxima, Phalaris arundinacea)* im Laufe der Dekomposition von K und Stickstoff *(Phragmites* und *Phalaris)* sowie von Phosphor *(Glyceria maxima)* jene Elemente relativ schnell frei, die für die Nährstoffanreicherung im Seewasser besonders gefährlich sind.

c) *Der globale Verlust an Mikroelementen und die Zersetzungsgeschwindigkeit*

Die prozentualen Gewichtsverluste (in%) an Mikroelementen (Fe, Mn, Zn) während der Dekomposition beträgt:

	Zn	Fe	Mn
Phragmites communis	64	47	40
Glyceria maxima	76	60	18
Phalaris arundinacea	48	40	10
Carex gracilis	50	42	33
Festuca pratensis	25	25	18

Bei jeder der untersuchten Arten wurde folgende Geschwindigkeit der Mikroelementenzersetzung festgestellt:

$$Zn > Fe > Mn$$

Zusammenfassung und Propositionen

Mit den ihr eigenen Boden- und Vegetationsverhältnissen bildet die Uferzonation einen organischen Teil des See-Ökosystems.

Mit dem Fortschreiten vom Land zum Wasser hin und mit der Zunahme der Feuchtigkeit bzw. der anaeroben Verhältnisse ändern sich auch mehrere Bodenfaktoren.

Von den höheren zu den niedrigeren Höhenlagen zu steigt der Gehalt des Bodens an organischen Stoffen und zugleich damit auch seine Adsorbtionskapazität, ferner die Zahl der adsorbierten Kationen, sowie der Gehalt des Bodens an Phosphor, Stickstoff und leicht aufnehmbarem Kalium.

Bei anhaltender Senkung des Wasserspiegels kommt es in der Uferzone zum Übergang zu aeroben Bodenverhältnissen und damit zu einer intensiven Mineralisierung der unter den anaeroben Verhältnissen angereicherten organischen Stoffe. Die hierbei frei werdenden biogenen Elemente, besonders aus der Umsetzung NO_3—N, bilden eine potentielle Gefahrenquelle.

Der Seewasserstand des Balaton von 115 cm (in bezug auf den Nullpunkt bei Siófok) muss unbedingt konstant gehalten werden. Bei anhaltend hohem Wasserstand verlangsamt sich infolge der anaeroben Verhältnisse in der Uferzone die Dynamik der Mineralisierung der Moorwiesen und Moorböden und somit der Prozess des Einschwemmens der durch die Mineralisierung frei werdenden Nährstoffe in den See. Die Stabilisierung des Bodengehalts an organischen Substanzen verhindert die Herabsetzung der Bodenadsorbtionskapazität und Filterwirkung.

Die Ufervegetation »filtert« dank ihrem grossen Nährstoffanreicherungs-Vermögen einerseits die vom Land her einströmenden Nährstoffe, während sie andererseits die bereits ins Wasser gelangten »ausfiltert«.

Die Uferzone und die natürliche Ufervegetation bedürfen in zunehmendem Masse gezielten Schutzes. Ähnlich wie in den Umweltschutzgesetzen des Auslandes müsste der Schutz der Uferstreifen sämtlicher natürlicher Gewässer in Rechtsnormen festgesetzt werden. Nach dem Umweltschutzgesetz der Deutschen Demokratischen Republik muss in den Uferzonen natürlicher Gewässer ein 200 m tiefer Streifen frei bleiben, d. h. er darf für keine wie immer geartete Zwecke in Anspruch genommen werden. Der Schutz der Rohr-, Binsenkraut-, Schilf- und anderen Bestände ist besonders dort von eminenter Wichtigkeit, wo die Uferzone reich an Nährstoffen ist, bzw. in der Nähe von

Einmündungen fliessender Gewässer (am Balaton z.B. nahe der Zala-Mündung), die den See mit vielen organischen und Nährstoffen belasten.

Die Zersetzung des Pflanzenmaterials der Uferzone vermag dem Seewasser grosse Mengen biogener Elemente zuzuführen und damit eine Nährstoffanreicherung zu verursachen, weshalb die Pflanzen des Uferstreifens regelmässig gemäht werden müssen, und auch die Entfernung der Mahd nötig ist.

Da sie grosse Mengen biogener Elemente zu binden vermögen, bedürfen die natürlichen Uferzonen der Buchten von Keszthely und Szigliget, sowie die Schilfrohrbestände des Nordufers des Balaton des gesteigerten Schutzes.

Die Pflanzen der Uferzone zersetzen sich verhältnismässig rasch, und ebenso geht die Zersetzung jener biogenen Elemente relativ schnell und in hohen Prozenten vor sich, die eine Nährstoffanreicherung im Wasser verursachen können.

Auch die Geschwindigkeit der Zersetzung der biogenen Elemente macht es erforderlich, die abgestorbenen Pflanzen am Ende der Vegetationszeit zu entfernen.

LITERATUR

BAILEY, G. W.—WHITE, J. L. (1964): Review of Adsorption and Desorption of Organic Pesticides by Soil Colloids with Impactions Concerning Pesticide Bioactivity. J. Agric. Food Chem. **12,** 324—332.

BALLENEGGER, R.—DI GLÉRIA, J. (1962): Talaj- és trágyavizsgálati módszerek (Methoden der Boden- und Stalldünguntersuchungen). Budapest, 1—410.

BITTMANN, E. (1968): Landschaftspflege an Gewässern. In: BUCHWALD, K.—ENGELHARDT, W. Handbuch für Landschaftspflege und Naturschutz. Bd. 2, 350—374.

COOKE, P. (1969): Atomic absorption spectrophotometry. Pye Unicam Ltd., Cambridge, 1—44.

DIETRICH, K. R. (1973): Die Abwehr der Eutrophierung der Gewässer als Umweltschutzmassnahme. Zeitschr. f. Kulturtechn. u. Flurbereinigung **14,** 1—20.

FELFÖLDY, L.—TÓTH, L. (1970): A mezőgazdaság kemizálásának hatása a vízgazdálkodásra II. (Die Auswirkungen der Chemisierung der Landwirtschaft auf die Wasserwirtschaft II.) Vízügyi Műszaki Gazdasági Tájékoztató **25,** Budapest 1—196.

GESSNER, F. (1939): Die Phosphatarmut der Gewässer und ihre Beziehungen zum Kalkgehalt. Int. Rev. Ges. Hydrobiol. **40,** 197—207.

HARPER, H. J.—DANIEL, H. (1939): Chemical Composition of Certain Aquatic Plants. Bot. Gaz. **69,** 186—189.

JAKUCS, P.—MAROSI, S.—SZILÁRD, J. (1971): Adatok a Balaton déli partvidékének mikroklimatikus sajátosságaihoz (Beiträge zu den mikroklimatischen Eigentümlichkeiten des südlichen Balatonufers). Földrajzi Értesítő **20,** 239—259.

JENNY, H.—GESSEL, S. P.—BINGHAM, F. T. (1949): Comparative Study of Decomposition Rates of Organic Matter in Temperate and Tropical Regions. Soil Sc. **2,** 419—432.

KÁRPÁTI, I.—VARGA, GY. (1970): A Keszthelyi-öböl hínárvegetációja kutatásának eredményei (Die Resultate der Laichkräuterforschung in der Bucht von Keszthely). A Keszthelyi Agrártud. Főiskola Közleményei **12/5,** 1—67.

KOVÁCS, M. (1974): Bodenindikation der dominanten Pflanzen von Kontaktgesellschaften in den Wiesengesellschaften. Acta Botanica Acad. Scient. Hung. **20,** 93—102.

MACKENTHUN, K. M. (1962): A Review of Algae, Lake Weeds and Nutrients. J. Water Poll. Contr. Fed. **34,** 1077—1085.

MULLIGAN, H. F.—BARANOWSKI, A. (1969): Growth of Phytoplankton and Vascular Aquatic Plants at Different Nutrient Levels. Verh. Int. Ver. Limnol. **17,** 802—810.

NÉMETH, I.—TÓTH, A. (1974): Művelési ágak környezetminőségre gyakorolt hatásainak vizsgálata különös tekintettel a Balaton vízgyűjtőjére (Untersuchung einzelner Anbauzweige auf ihre Auswirkungen auf die Umweltbeschaffenheit mit besonderer Berück-

sichtigung des Balaton-Einzugsgebietes). In: Az 1973. évi környezetvédelmi kutatási eredmények (Die Resultate der Umweltschutz-Forschungen 1973). Mezőgazd. és Élelmezésügyi Minisztérium, Budapest, 115—129.

PAECH, K.—TRACEY, M. V. (1956): Moderne Methoden der Pflanzenanalyse. Berlin—Göttingen—Heidelberg. 1—542.

PINKOLA, L.—TÓTH, L. (1971): A Balaton pesticid-viszonyainak feltárása (Erschliessung der Pestizid-Verhältnisse des Balaton). Vituki-Beszámoló 1968, 228—244.

RAPP, M. (1967): Étude expérimentale de la libération d'éléments minéraux lors de la décomposition de litières d'essences méditerranéennes. C. R. Acad. Sc. Paris, **264,** 797—800.

RAPP, M. (1971): Cycle de la matière organique et des éléments minéraux quelques ecosystèmes méditerranéens. Recherche cooperative sur programme du C.N.R.S. No. **40,** 1—184.

SEIDEL, K. (1966): Reinigung von Gewässern durch höhere Pflanzen. Naturwissenschaften **53,** 289—297.

SOÓ, R. (1933): A Balatonvidék növényszövetkezeteinek szociológiai és ökológiai jellemzése (Die soziologische und ökologische Kennzeichnung der Pflanzengesellschaften des Balatonufers). Magy. Tud. Akad. Math. és Term.tud. Ért. **50,** 669—712.

STUGREN, B. (1974): Grundlagen der allgemeinen Ökologie. Jena, 1—223.

TÓTH, L. (1962): On some Chemical Properties of Wolffia arrhiza (L.) Wimm. Annal. Inst. Biol. (Tihany) Hung. Acad. Scient. **29,** 275—282.

TÓTH, L. (1972): Balatoni hínárok kémiai összetételéről (Über die chemische Zusammensetzung der Laichkräuter des Balaton). VITUKI-Beszámoló (1969). 398—405.

TÓTH, L. (1972): A Balaton hínárosodásának jelenlegi állapotáról (Über den gegenwärtigen Stand des Laichkrautwuchses im Balaton). Vízminőségi és víztechnológiai kutatási eredmények (Resultate der Wasserqualitäts- und wassertechnologischen Forschung) 2. VITUKI, Budapest, 16—25.

TÓTH, L. (1972): On the Chemical Composition of Submerged Aquatic Plants in Lake Balaton. Vízminőségi és víztechnológiai kutatási eredmények 2 (Resultate der Wasserqualitäts- und wassertechnologischen Forschungen 2). VITUKI, Budapest, 48—55.

TÓTH, L. (1972): Reeds Control Eutrophication of Balaton Lake. Water Research Pergamon Press **6,** 1535—1539.

TÓTH, L. (1974): Hidrobiológiai kutatások a Balaton vízminőségszabályozásának érdekében (Hydrobiologische Forschungen zwecks Regelung der Beschaffenheit des Balaton-Seewassers). VITUKI 1974. évi tudományos napok. Budapest — Vervielf.

TÓTH, L.—TÖLG, I.—KONTUR, GY. (1969): A hínárirtás korszerű megoldása (Die moderne Lösung der Laichkräuterausmerzung). Vízügyi Műszaki Gazdasági Tájékoztató **2,** 1—105.

TÖLGYESI, GY. (1969): A növények mikroelemtartalma és ennek mezőgazdasági vonatkozásai (Der Mikroelementengehalt der Pflanzen und dessen Beziehungen zur Landwirtschaft). Budapest, 1—189.

WAGNER, G. (1966): Phosphatspeicherung und N/P-Quotient bei Laichkräutern in abwasserbelasteten Ufergebieten des Bodensees. Int. Rev. Ges. Hydrobiol. **51,** 229—235.

ZIMENKO, T. G. (1972): Dejatelnosti mikroorganismow i mineralisacija organičeskowo weščežtwa w torfjannych pocwach s rasnym urownem gruntovych wod. Izw. ANSSR. Sr. Biol. **6,** 846—853.

A vízi környezetvédelem a balatoni üdülőövezetben (Umweltschutz von Gewässern in der Erholungszone am Balaton). Orsz. Műszaki Fejlesztési Bizottság (OMFB), 9-20-7311-T (Studie). Budapest, 1—123.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1—2), pp. 107—126 (1976)

PHLEUM STUDIES I.

DATA ON THE TAXONOMY AND MORPHOLOGY OF PHLEUM BERTOLONII DC.* AND PHLEUM PRATENSE L.

By

D. KOVÁTS

BOTANICAL DEPARTMENT OF THE NATURAL HISTORY MUSEUM, BUDAPEST

(Received January 17, 1976)

Comparative morphological measurements were carried out on the culms of the diploid (2n = 14) *Phleum bertolonii* DC. and the hexaploid (2n = 42) *Phleum pratense* L. On the basis of the measurements and observations it can be stated that differences in size occur in the epidermal cells of culms, spikelets and grains, numbers and length values of the internodes, at internode and node levels, when considering also the number of tubers and innovations. The investigations were carried out on plants obtained from original habitats and experimental gardens.

Introduction

In the Hungarian flora, the species character of the diploid (2n = 14, NORDENSKIÖLD, 1941; 1945; DARLINGTON—WYLIE, 1955) *Phleum* species (*Ph. bertolonii* DC.) has been mistaken. Thus it is not considered an independent species but a subspecies of the hexaploid (2n = 42) *Phleum pratense* L., or a variety of it, under the following names: *Phleum pratense* ssp.? var.? *nodosum* (L.) Schreb. p. p.; *Phleum pratense* ssp.? var.? *Bertolonii* (DC.) A. et G. p. p. (JÁVORKA, 1925 p. 71); *Ph. pratense* ssp. *nodosum* (L.) Richt. p. p. (SOÓ—JÁVORKA, 1951 p. 958); *Ph. pratense* ssp. *nodosum* (L.) Trabut p. p. (SOÓ—KÁRPÁTI, 1968 p. 781; SOÓ, 1973 5. p. 407).

It should be mentioned that DEGEN in his work entitled Flora Velebitica also wrote of *Ph. bertolonii* DC. as early as 1936, and according to his collections which have been preserved in the Herbarium of the Natural History Museum, he indeed meant the diploid *Phleum* under the above name. In his work cited above the *Ph. pratense* L. var. *nodosum* Auct. also occurs and in his collection under this name there are also *Ph. pratense* L. stems.

* Concerning the types and nomenclature, there are a few questions still awaiting clarification for me. I intend to deal with them in a later publication. Until that time, on the basis of the German (HERMANN, 1956), and the English (CLAPHAM—TUTIN—WARBURG, 1959; 1962; HUBBARD, 1968) literature, I use the name *Phleum bertolonii* DC. for the denomination of the diploid (2n = 14) species (p. p. syn. *Phleum nodosum* L.).

The Hungarian taxonomists separated the two plants on the basis of the nodosus character which is of no taxonomical value, therefore it is completely obvious that they were unable to recognize the species character of the *Ph. bertolonii* DC.

In the newer works on European flora, the diploid *Phleum* appears as an independent species; under the name *Ph. nodosum* L. (LINNÉ, 1759): DALLATORRE—SARNTHEIN (1906), GROSSHEIM (1928), LID (1952); HUBBARD (1954), BUTCHER (1961) and HESS—LANDOLT—HIRZEL (1967); and under the name *Phleum bertolonii* DC. (DE CANDOLLE 1813): GROSSHEIM (1928), HERMANN (1956), DANDY (1958), CLAPHAM—TUTIN—WARBURG (1959), CLAPHAM—TUTIN—WARBURG (1962) and HUBBARD (1968).

In other works, the diploid *Phleum* species appears as a subspecies, or a variety, of *Ph. pratense* L.: VISIANI (1842); FIORI (1896—1908); FIORI (1923—1925); HEGI (1927); BORDZILOWSKIO—LAVRENKO (1940); DOSTAL (1954); JORDANOV (1963); SAVULESCU—POP (1972); or *Ph. pratense* L. s. l.: SCHMEIL—FITSCHEN (1965); or as a minor species: EHRENDORFER (1973).

In Hungary, *Ph. bertolonii* DC. grows in several habitats as a progenitor of the hexaploid *Ph. pratense* L. (NORDENSKIÖLD, 1945), in original habitats and in communities, mainly on acidic rocks substrates. *Ph. pratense* L. also grows on water logged meadows, marshes, grazing lands and hayfields (SOÓ—JÁVORKA, 1951; SOÓ—KÁRPÁTI, 1968; MÁTHÉ—HESZKY, 1972; SOÓ, 1973); in weed communities and on wastes.

When separating the two *Phleum* species, the designation "nodosus" originating from LINNÉ (1759) is disturbing since the nodosus character in this case cannot be used as a separating characteristic as is clear from the works of the following authors: HUBBARD (1954; 1968), BUTCHER (1961), HESS—LANDOLT—HIRZEL (1967).

So far as I know, the most thorough description originates from HUBBARD; on the basis of this, the separation of the two *Phleum* species is justifiable.

According to NORDENSKIÖLD (1945), the two species can be clearly separated genetically, cytologically and ecologically. He says that they are morphologically very near to each other being different only in size. He even details accurate differences in sizes of the organs of the two species.

In Hungary, ÚJHELYI deals with the evolutionary research into *Gramineae (Poaceae)*. He uses the method of exact examination of the histological characteristics when describing taxonomically the various species (ÚJHELYI, 1938), or pointing out affinities in *Sesleriae* (ÚJHELYI, 1959). The evolutionary examination of the European *Koeleriae* led to the establishment of natural evolutionary rows or series (ÚJHELYI, 1961—1974). In the course of morphological and anatomical examinations, several researchers have already dealt with the development of internode length in the shoots of various plants. In

Hungary, among others, STIEBER—PÁL (1957; 1959) and STIEBER (1972) examined it in wheat and rye; BARÁTH—ifj. MÁTHÉ—MÁTHÉ (1973) in *Solanum* genus; KOVÁTS (1973) in *Lithospermum purpureo-coeruleum* L.; SZUJKÓ-LACZA—SZŐCS (1976) in *Pimpinella anisum* L.

In the present work, I intend to provide, on the basis of morphological and anatomical data as well as on the basis of the investigations carried out up till now, the reasoning behind the separation of the two *Phleum* species. Owing to the difference in the "ploid" levels of the two species, the diploid *Ph. bertolonii* DC. is far smaller than the hexaploid *Ph. pratense* L.

Materials and method

The overwhelming majority of the plants were collected from various parts of the country by József ÚJHELYI, who called my attention to this topic. It was at his inspiration that I originally started to deal with *Phleums*. *Ph. bertolonii* DC. plants were provided from Hárskút in the Bakony Mountains, by Sándor TÓTH. In the last three years I myself have also joined in collecting *Phleum*.

My *Phleum* plants all grow in identical conditions in an experimental garden; they are planted side by side at a distance of about 40 cm from each other. The plants grown in the experimental garden, and which have been examined and measured morphologically and anatomically in the frame-work of the present work, were obtained from the following habitats:

Ph. bertolonii DC.

Hungaria septentrionalis. In saxosis andesiticis montis Salgóvár ad pag. Salgó, prope opp. Salgótarján. Alt. cca 600 m.s.m. 4. VII. 1966. leg. J. ÚJHELYI.

Hungaria occidentalis, Őrség. In pratis montis Nagyhegy, ad pag. Zalalövő, prope opp. Zalaegerszeg. Alt. cca. 250 m.s.m. 30. IX. 1970. leg. E. VALKÓ et J. ÚJHELYI.

Hungaria occidentalis. In pratis siccis pag. Hárskút, montium "Bakony hegység", prope opp. Zirc. 1. X. 1970. leg. S. TÓTH et 30. IX. 1975. leg. J. ÚJHELYI, S. TÓTH et D. KOVÁTS.

Ph. pratense L.

Hungaria centralis. In urbe Budapest. Ad ripam lacus "Városligeti tó". In ruderalis. VIII. 1966. leg. J. ÚJHELYI.

Hungaria occidentalis. Őrség. In pratis montis Nagyhegy, ad pag. Zalalövő, prope opp. Zalaegerszeg. Alt. cca. 250 m.s.m. 30. IX. 1970. leg. E. VALKÓ et J. ÚJHELYI.

Hungaria septentrio-orientalis. Montes Mátra-hegység. In pratis sylvaticis montis Kékestető, prope opp. Gyöngyös, solo andesitico. Alt. 1000 m.s.m. 23. VII. 1971. leg. J. ÚJHELYI.

Hungaria septentrio-orientalis. Montes Bükk-hegység. In pratis montis Nagyeged, apud opp. Eger. Solo calcareo. Alt. cca. 400 m.s.m. 8. IX. 1971. leg. S. TÓTH.

The *Phleum* plants were dug up from the experimental garden on August 24, 1975.

The other portion of the experimental material was collected for processing from the original habitat, the fields around Pilisszentlászló village, in the Pilis Mountains (on October 29, 1975); *Phleum pratense* L. var. *pilisense* Boros (1963) described by Ádám BOROS was obtained from these fields.

Ph. bertolonii DC.: Hungaria centralis. In montibus "Pilis-hegység", ad margines sylvarum, prope pag. Pilisszentlászló, solo andesitico. Alt. cca. 500 m.s.m. 29. X. 1975. leg. D. KOVÁTS.

Ph. pratense L.

Hungaria centralis. In montibus "Pilis-hegység", ad margines viarum, prope pag. Pilisszentlászló, solo andesitico. Alt. cca. 500 m.s.m. 29. X. 1975. leg. D. KOVÁTS.

Cytological examinations, and chromosome counting were carried out on the root apex of seedlings and of full-grown plants; for fixation CARNOY-type solution dyeing carmine-acetic acid was used (ÖSTERGREN—HENSEN, 1962; SÁRKÁNY—SZALAI, 1964). Skin preparation from culms (ÚJHELYI, 1954) were from the uppermost internodes, below the panicles, where the culm becomes free from the sheath. All the preparations were dyed with toluene, then photomicrographed on NP 15 ORWO negatives, with a Zeiss NfPK microscope, at identical magnification.

The lengths of the internodes are given in cm, the average values illustrated in graphs; significance is calculated at internode levels by using tests t and d of two samples (SVÁB, 1967; HAJTMAN, 1968).

The developmental stages and the phenophases of the specimens examined were labelled after SZUJKÓ-LACZA—FEKETE (1973) (Tables 1 and 2).

Results and discussion

Although the two *Phleum* species are easily distinguishable on the basis of growth and external measurements, especially in their fully-grown state, I myself verified whether the plants under investigation were indeed individuals of diploid (2n = 14) and hexaploid (2n = 42) chromosome numbers by counting the chromosomes of a few of the experimental plants.

According to my observations, the epidermal cells of culms below the panicles are smaller in *Ph. bertolonii* DC. than those at the same level in *Ph. pratense* L. of the same growth stage (Photographs 1 and 2).

The differences in size also exist with regard to the much smaller spikelets and grains in *Ph. bertolonii* DC. and those of *Ph. pratense* L. (Photograph 3, NORDENSKIÖLD, 1945, pp. 94, 99, 102; HUBBARD, 1954, pp. 294—7, 1968, pp. 320—3).

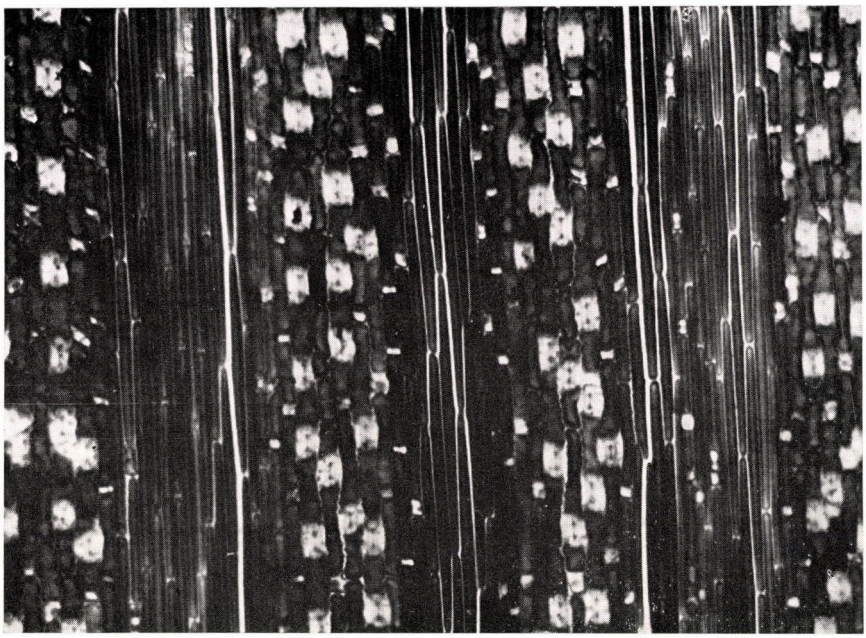
Distribution of culms according to internode numbers

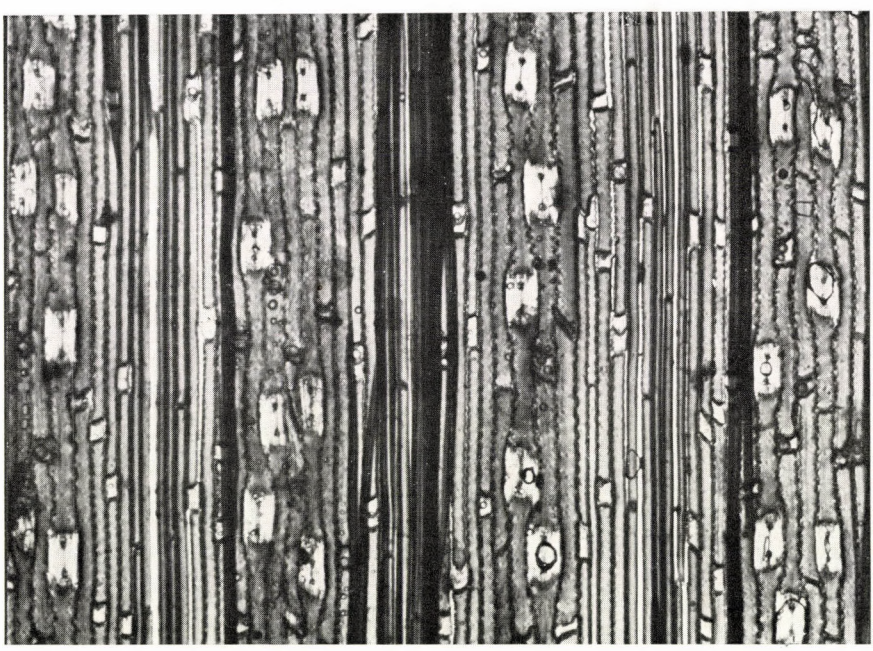
I counted the internodes of the culms bearing panicles (relative main axis) on 4×30 (*i.e.* 120 culms). I compared the two species from this point of view and examined the differences between plants from original habitats and those from experimental gardens (Fig. 1).

According to the observations, the internode numbers of culms in *Ph. bertolonii* DC. grown under natural conditions show greater variance than do those of *Ph. pratense* L. since in the former, greater as well as smaller internode numbers are to be found. Under garden conditions, the internode number of *Ph. bertolonii* DC. is much greater than that of *Ph. pratense* L. Variance is also greater here in the case of *Ph. bertolonii* DC. (Fig. 1).

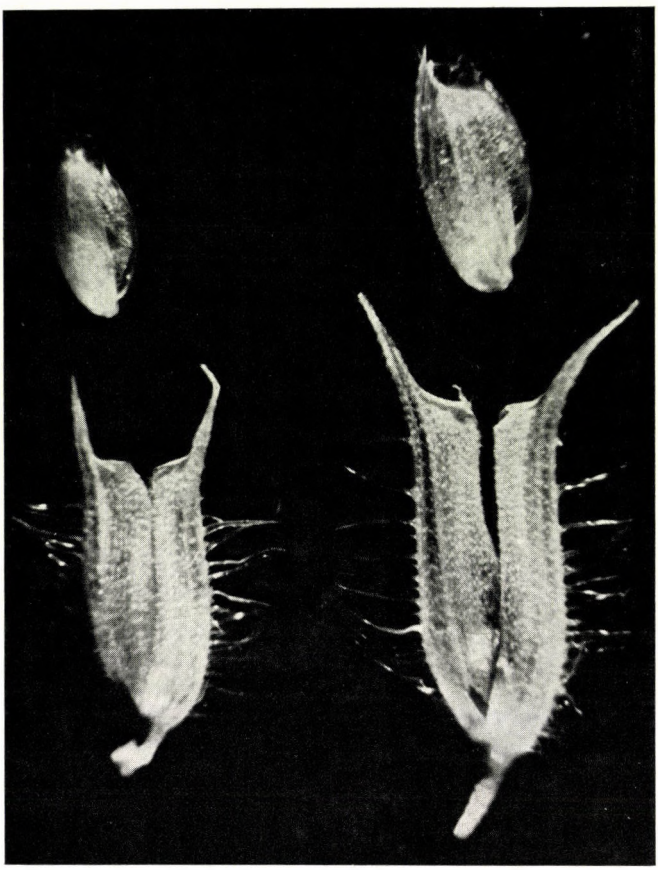
The culms of *Ph. bertolonii* DC. examined have 5, 6, 7, 8, 9, 10 internodes in original habitats, while those of *Ph. pratense* L. are only of 6, 7, 8 internodes. The latter plants show the smallest variation, their culms are only of 3 types of internode number, while *Ph. bertolonii* DC. has double this number, that is 6 kinds (Fig. 1).

In garden conditions, the culms of *Ph. bertolonii* DC. are of the greatest variance with regard to internode numbers in the examined material, since they have 8, 9, 10, 11, 12, 13, 14, 16 internodes, that is 8 types; while those of *Ph. pratense* L. only have 6, 7, 8, 9, 10 internodes, that is 5 types. The distribution according to internode numbers of culms in *Ph. bertolonii* DC. shows a greater variation than that of *Ph. pratense* L. (Fig. 1).





Photographs 1 and 2. Epidermal cells of *Phleum bertolonii* DC. culms, and *Ph. pratense* L. culms, below the panicles ($\times$ 250 in every case)



Photograph 3. Spikelets and grains with upper and lower glumes of *Ph. bertolonii* DC. and *Ph. pratense* L. (× 14)

A comparison between the two species on the basis of their vegetative spreading

In the experimental garden, decumbency and the growth of stems planted 40 cm apart are not hindered by other plants, it is for this reason that under garden conditions the strongly innovational *Ph. bertolonii* DC. stems were able to develop. Their culms lie in a decumbent position, some of them extending to a length of 72 cm (Photographs 4 and 5).

The *Ph. pratense* L. stems, on the other hand, are not innovational in character, even under identical garden conditions, or, alternatively they have innovations only to a small extent in spite of the fact that they have sufficient space for development, similarly to the *Ph. bertolonii* DC. stems (the distance between the various stems is 40 cm). Their culms mostly grow upright (Photograph 6), they never creep along ground. They are only rarely broken at the nodes, which on the other hand is a general characteristic of the culms of *Ph.*

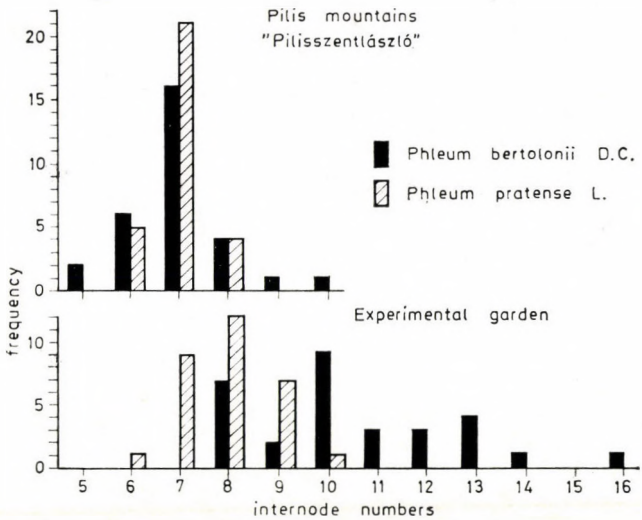
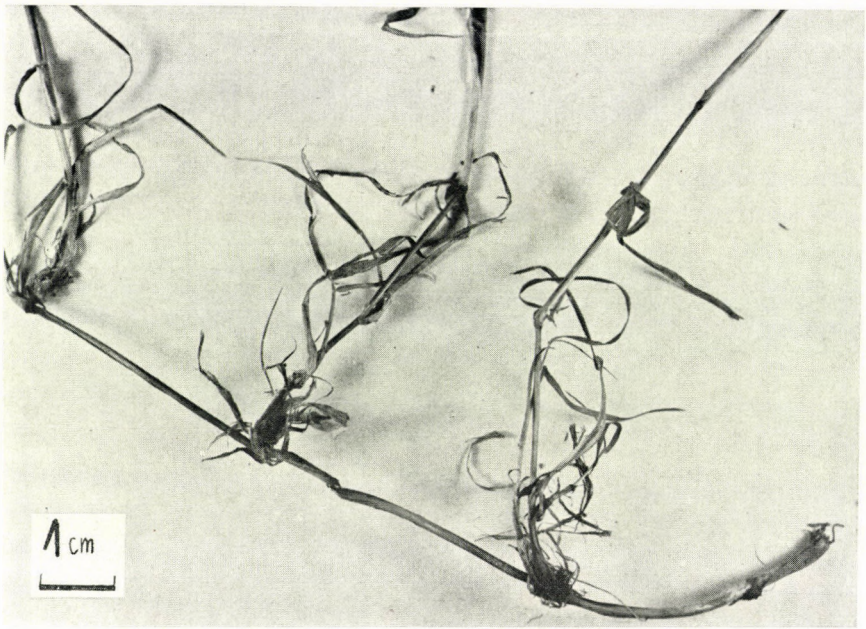


Fig. 1. Distribution of culms by internode number

bertolonii DC. The reclining culms, innovations of relative main axis, are in many cases develop roots and they therefore reproduce themselves vegetatively (Photographs 5 and 7).

Photograph 4. Ph. bertolonii DC. grown in the experimental garden; the plant is loose, it has innovations, its culms are decumbent



Photograph 5. The decumbent relative main and side axes exhibiting branching at several node levels of *Ph. bertolonii* DC. grown in the experimental garden (original magnitude)

Distribution of the internode lengths of culms by levels

On the culms of experimental garden *Phleums* collected and measured on July 24, 1975, the flowering was finished, the ripening of fruit was begun, the panicles were still whole, marks of disorganization could not be seen on them, unlike in the case of culms from Pilisszentlászló, which were collected and measured on October 29 in the same year. In those the seeds had already ripened, in fact, most of them had dropped, the panicles were broken and had come off (therefore, their length could not be measured).

The internode lengths by levels of the culms of the two species were measured and compared with one another. The internode numbers of the culms examined varied to a very great extent (Fig. 1). The comparison of the various internode levels was begun from below; that is from the rooty, underground, tuberously thickened internodes. In this way, the most characteristic, longest internodes of the various culms, that is, those under the panicles did not fall into the same level. When the comparison started from above, the lower internodes became displaced; therefore, the internode lengths of the culm material were compared in various ways.

Of the culms from Pilisszentlászló and from the experimental garden, I selected the ones which had the most frequently occurring internode numbers and I measured their identical internode levels. As a result, from the Pilis-

Photograph 6. From the dense stocks of *Ph. pratense* L. the culms climb high in an upright manner

szentlászló material of the two species only the culms having 7 internodes, while from the garden material only those having 8 internodes were subjected to comparison (Fig. 2a, b; Table 1). In these, the shifting of the internodes of identical level was eliminated.

The internode lengths, from the average of 66 culms, are graphically demonstrated (Fig. 2a, b). Curve S, characteristic of culms whose growth is not unlimited (TROLL, 1937), is well depicted in the case of the non-decumbent *Ph. pratense* L. culms obtained from the original habitat, while in the case of *Ph. bertolonii* DC. (also obtained from the original habitat) it is exponential (Fig. 2a). Under garden conditions, the internode lengths slightly fluctuate initially, before reaching the maximum, in both of the species (Fig. 2b).

Naturally, the lengths of the internodes in the hexaploid *Ph. pratense* L. are greater than those of the diploid *Ph. bertolonii* DC. With regard to the

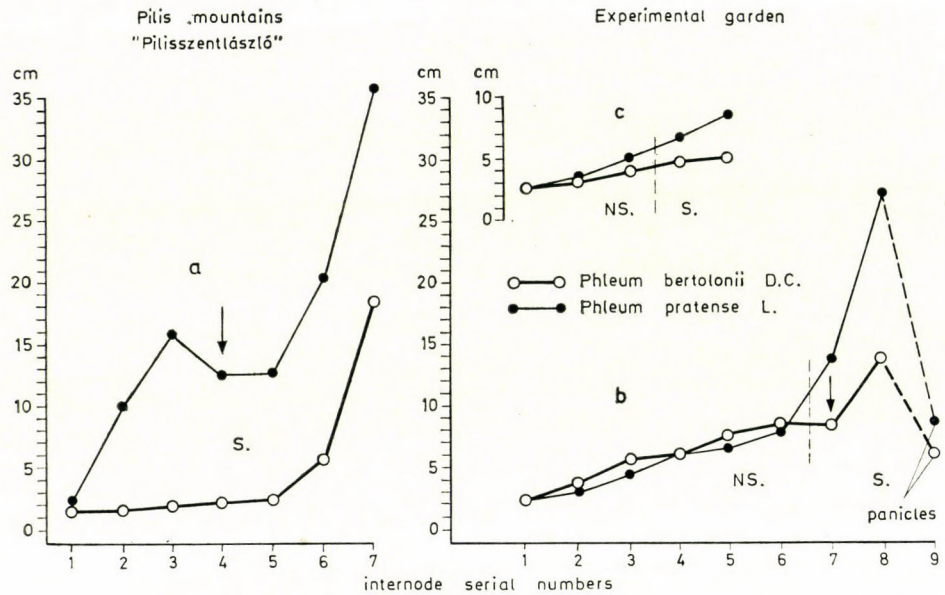


Fig. 2. Distribution of internode lengths by levels of the culms

culms growing in the original habitats there is a significant difference of 1%, at all the internode levels, between the two species (Fig. 2a, Tables 1 and 2). With regard to the culms having 8 internodes of the two *Phleum* species grown in the experimental garden, it is only the average lengths of the panicles and of the two uppermost internodes (internodes 7 and 8) that differ significantly, while the lengths of the 6 lower internodes do not (Fig. 2b, Table 1).

The experimental material showed that the internodes of the culms having fewer internodes — in the case of *Ph. bertolonii* DC., the culms having 8 internodes, under garden conditions the ones which have the smallest number of internodes (Fig. 1) — are in general longer than those having a great number of internodes. This is probably why the lower internodes of the culms having few internodes in the decumbent *Ph. bertolonii* DC., grown in garden conditions, extend further than those of the hexaploid *Ph. pratense* L. at identical levels. This difference in length is not significant (Fig. 2 b, Table 1). As soon as the upper internodes of the *Ph. pratense* L. are longer, the internode length differences in the two species become significant (internodes 7 and 8 and the length of the panicle).

In a comparison between the lower internodes of the culms of *Ph. bertolonii* DC. grown in the original habitat and those in garden conditions, the internodes of the former are remarkably shorter than those of the latter. On an average, it is only the internode 6 the length of which is slightly longer than 5 cm (5.3 cm), whereas in the culms grown in the experimental garden, the

Table 1

Averaged data of internode lengths, cumulate lengths and significances by internode levels of the 7 and 8 internode culms of Phleum bertolonii DC. and Phleum pratense L. grown in the original habitat and in the experimental garden, based on 40 and 26 data

Date	Developmental stages and phenophases	Internode serial numbers	*Phleum bertolonii*		*Phleum pratense*		Significance	Level, %
			average length in cm	cumulate length in cm	average length in cm	cumulate length in cm		
Culms of 7 internodes from "Pilisszentlászló"								
29. X. 1975	24	1	1.3	1.3	2.3	2.3	S	1
	34	2	1.4	2.7	10.0	12.3	S	1
	41, 42	3	2.0	4.7	15.8	28.1	S	1
Average height, in cm		4	2.1	6.8	12.7	40.8	S	1
without panicle		5	2.6	9.4	12.9	53.7	S	1
Ph. bertolonii: 32.9		6	5.3	14.7	20.5	74.2	S	1
Ph. pratense: 110.0		7	18.2	32.9	35.8	110.0	S	1
Culms of 8 internodes from experimental garden								
24. VIII.	24	1	2.3	2.3	2.3	2.3	NS	
1975	33	2	3.6	5.9	3.1	5.4	NS	
		3	5.6	11.5	4.4	9.8	NS	
		4	6.1	17.6	6.1	15.9	NS	
Average height, in cm		5	7.5	25.1	6.8	22.7	NS	
without panicle		6	8.8	33.9	8.5	31.2	NS	
Ph. bertolonii: 56.2		7	8.5	42.4	13.6	44.8	S	1
Ph. pratense: 72.1		8	13.8	56.2	27.3	72.1	S	1
		panicle	6.1	62.3	8.9	81.0	S	5

third internode is already of an average length of 5.6 cm (Fig. 2a, b, Table 1). This is all the more remarkable as, presumably, the garden culms — which are still at the beginning of the fruiting stage — will further increase in length (even though this may be only a few mm). In the fully-grown state, the average length of the uppermost internodes beneath the panicles is indeed much greater (18.2 cm) in the original habitat, than in garden conditions (13.8 cm) not much later than the post-flowering state. In the case of the *Ph. pratense* L., all the internodes of the fully-grown culms (except the lowermost) in the original habitat are on the average longer than those of the garden culms in the post-flowering state (Fig. 2a, b, Table 1).

In order to be able to evaluate not only the culms having 7 and 8 internodes, I have made a comparison also between the averages of the internode lengths of all the culms measured (more than 200). The main problem with

Table 2

Averaged data of internode lengths, cumulate lengths and significances by internode levels of the culms of Phleum bertolonii DC. and Phleum pratense L. grown in the original habitat and in the experimental garden, from the complete investigational material, based on over 200 data

Date	Developmental stages and phenophases	Internode serial numbers	*Phleum bertolonii*		*Phleum pratense*		Significance	Level, %
			average length in cm	cumulate length in cm	average length in cm	cumulate length in cm		
"Pilisszentlászló"								
29. X. 1975	24	1	1.4	1.4	2.8	2.8	S	1
	34	2	1.6	3.0	9.1	11.9	S	1
	41, 42	3	2.1	5.1	13.4	25.3	S	1
		4	2.6	7.7	11.4	36.7	S	1
		6	1.6	33.7	8.5	97.7	S	1
		5	2.1	32.1	13.8	89.2	S	1
		4	2.0	30.0	11.9	75.4	S	1
		3	2.9	28.0	11.8	63.5	S	1
		2	6.1	25.1	18.3	51.7	S	1
		1	19.0	19.0	33.4	33.4	S	1
Experimental garden								
24. VIII. 1975	24	1	2.3	2.3	2.6	2.6	NS	
	33	2	3.1	5.4	3.7	6.3	NS	
		3	4.0	9.4	5.0	11.3	NS	
		4	4.5	13.9	6.3	17.6	S	1
		5	5.1	19.0	8.2	25.8	S	1
		6	4.8	47.3	4.6	69.2	NS	
		5	5.1	42.5	6.3	64.6	S	5
		4	5.7	37.4	7.0	58.3	S	5
		3	7.0	31.7	9.1	51.3	S	1
		2	6.7	24.7	14.1	42.2	S	1
		1	13.2	18.0	29.5	38.1	S	1
		panicle	4.8	4.8	8.6	8.6	S	1

regard to the differences in internode numbers, which still awaits solution, was attempted to be avoided by measuring only up to a certain level of nodes from ebove downwards and *vice versa*. This way of measuring leads in principle to real values which are usable to some extent. I should like to emphasize, how-

ever, that this problem was not fully solved in this way, and I intend to deal with this question in greater detail in the future.

Internode lengths were measured from below upwards, up to internodes 4 and 5, as long as the non-significant differences (NS) turned into significant ones (S), and *vice versa*, that is from above, taking the longest internodes below the panicles as No. 1, downwards to internode 6, experimentally, as long as the difference S became NS (Fig. 2c, Table 2). Due to the causes mentioned above, the continuation of the comparison between the internode levels was not worth-while.

Now, after the averages of all the data have been compared, it can be stated that the internode lengths of the culms of *Ph. bertolonii* DC. and *Ph. pratense* L., originating from the original habitat of Pilisszentlászló, differ significantly on a 1% level, at 10 internode levels. The internodes of *Ph. pratense* L. are on the average much longer than those of *Ph. bertolonii* DC. (Table 2).

In measuring and comparing the whole material of investigation, a more significant difference is to be found between the two *Phleum* species grown in the experimental garden in the case of culms having several internode levels than in culms having only 8 internodes (Tables 1 and 2). In the case of all data the length of the upper 5 internodes is S in character, while in the case of culms having 8 internodes, only the upper 2 internodes are S in nature. When considering all the data, the 4th internode from below is already S, while in the case of culms having 8 internodes, only the 7th internode from below is S (Fig. 2b, c, Tables 1 and 2).

Since all the culms were considered, that is the *Ph. bertolonii* DC. culms having greater internode numbers and shorter internodes, too, the difference S occurred at more internode levels than when only the culms of *Ph. pratense* L., having longer internodes, were compared.

Distribution of the tubers and of the innovations by node levels*

I counted and compared the number of tubers and innovations on 4×33 (i.e. 132) culms. The number of tubers and of innovations is, in general, the greatest in relation to the lowermost nodes in most of the culms, their number decreases to a remarkable extent in the case of the upper nodes. The exceptions are the culms of the *Ph. bertolonii* DC. plants grown in garden conditions. These are of another character (Fig. 3).

* The tuberous thickening of the lowermost internodes and of a few upper internodes. I intend to deal with the description of their external and internal morphology, in one of my future publications. I use the term: tuber, after Arber (1965).

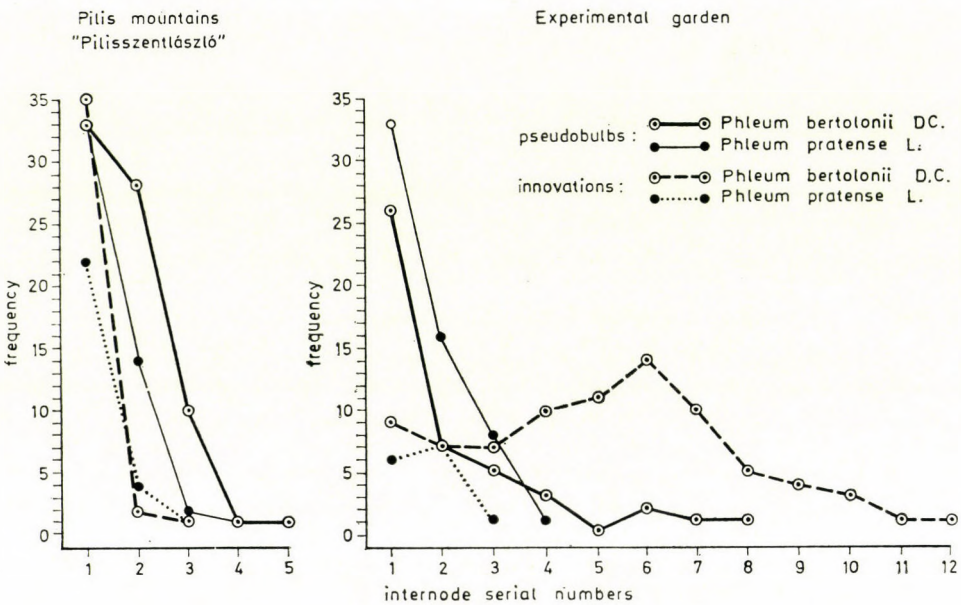
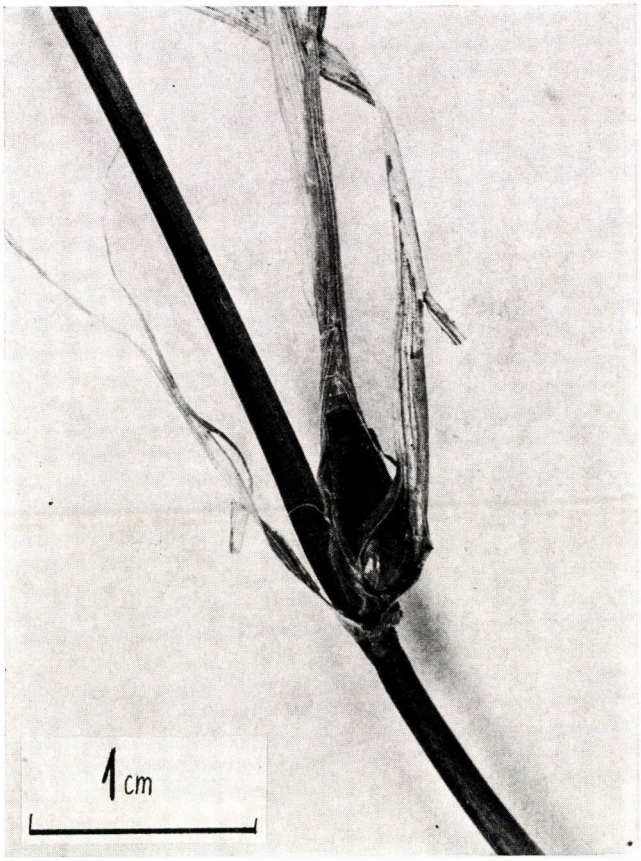


Fig. 3. Distribution of tubers (pseudobulbs) and innovations by node levels, in 132 culms

Let us consider first the tubers. In the case of both species, the lower part of the lowermost internode — in the *Ph. bertolonii* DC. species mostly the whole internode — thickened tuber (Photographs 7, 8, 9). This refers to 125 culms out of the 132; the 7 *Ph. bertolonii* DC. culms grown in the experimental garden were exceptions. On the other hand, in the case of the *Ph. bertolonii* DC. culms grown in the experimental garden, there were tubers even at internodes Nos 6, 7 and 8. On the other culms examined there were no tubers at such high internode levels. This is in connection with the greater number of internodes in *Ph. bertolonii* DC. culms (Fig. 1, 3), especially among garden conditions, where the culms lie in a decumbent position and develop roots (Photographs 4, 6 and 7).

The distribution of the number of innovations by node levels is similar to that of the tubers (Fig. 3). Naturally, most of the innovations are on the lowermost nodes, their number decreases on the upper nodes. In the plant examined, there are no innovations even at the 4th node. Deviations are also in this case the *Ph. bertolonii* DC. culms grown in garden and having many nodes, because they have innovations even on the 12th node. Most of the innovations — altogether 14 — occurred on the 6th node level in the 33 culms measured, *i.e.* more than on the lowermost nodes, where a total of only 9 innovations started to grow (Fig. 3).

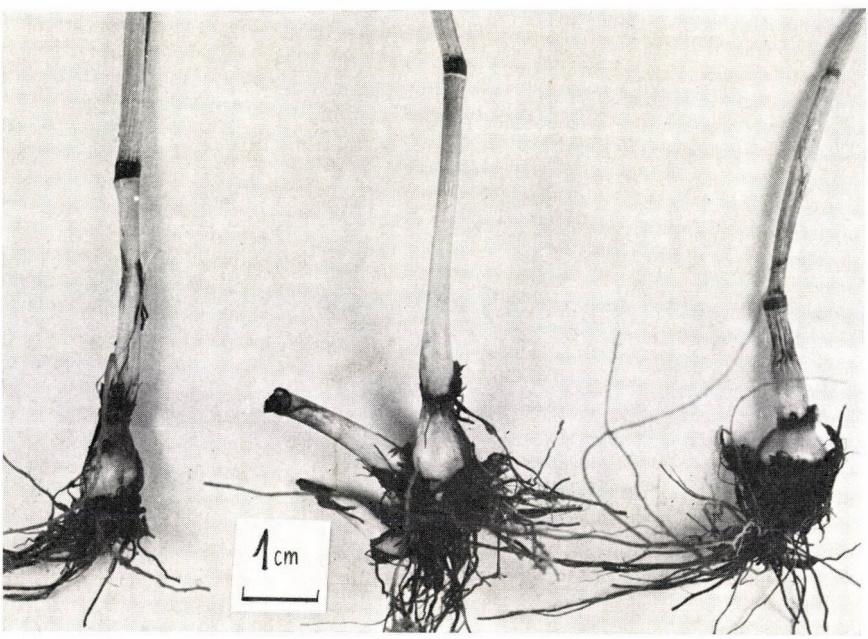


Photograph 7. The side culm ramifying from the relative main axis of *Ph. bertolonii* DC.; its first internode has tubers

In secondary, disturbed habitats, the number of *Ph. bertolonii* DC. tubers and the number of their innovations remarkably increase, whereas the number of the *Ph. pratense* L. tubers and of their innovations do not significantly change even under secondary conditions.

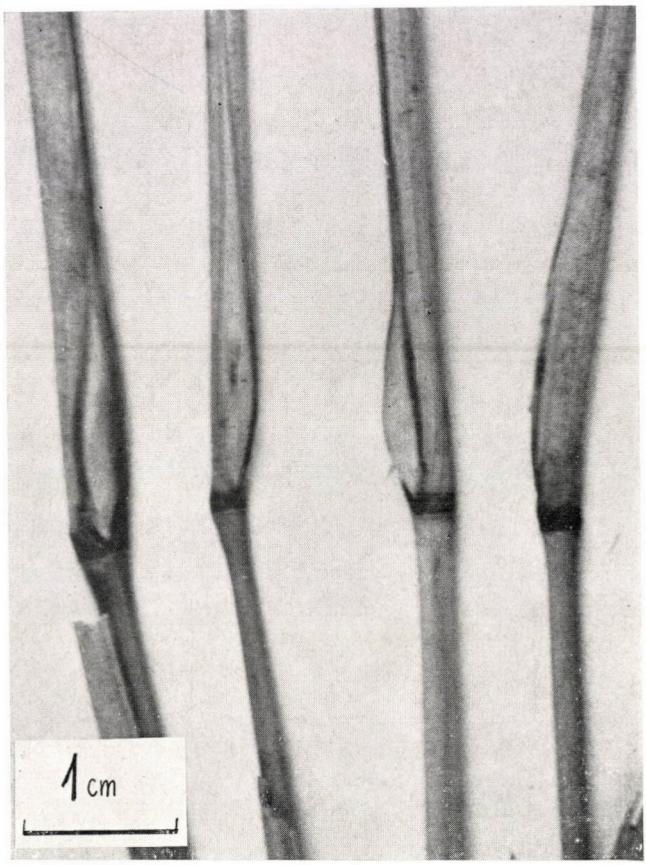
According to the observations, the innovations of the garden *Ph. bertolonii* DC. are mostly well developed by the middle of August, possibly they exhibit multifurcation (Photographs 4, 5). The first internodes of the branchings have tubers (Photographs 5, 7) and in many cases these already come off the relative main axis. Since under garden conditions there is space (the plants are 40 cm apart), the other plants do not hinder the plants lying along the ground, the side culms which have come off, and have tubers, continue their existence as independent geotrophic plants. They reproduce themselves vegetatively. I have not experienced this in the case of *Ph. pratense* L., even in garden conditions.

Photograph 8. The lower internodes of *Ph. pratense* L. have tubers (original magnitude)



Photograph 9. The lowermost internodes of *Ph. pratense* L. are completely "tuberouse d" this is conspicuous in the stems freed from leaf sheaths (original magnitude)

There is a difference between the two species also in the number of innovations by the node. By examining the culms (relative main axes) each separately, it can be stated that in both of the species, the most frequent occurrence



Photograph 10. Lower part of *Ph. pratense* L. upper internodes, with tubers

is that one innovation grows from one node. The case of two innovations starting from one node is also rather frequent, but to have three of them is already rare. By examining the culms of the two species by nodes, it is only the lowermost nodes from which two or three innovations start by node, while from the second and third nodes only one innovation grows. As opposed to this, from the fourth, sixth and seventh nodes of the garden *Ph. bertolonii* DC. culms two innovations start often by node. At the lowermost node I found three innovations only once out of the 33 cases.

In a comparison of all the node levels, it can be inferred that the number of tubers and innovations decreases from the lowermost nodes upwards. The number of tubers follows the decrease in number of innovations. The culms of garden *Ph. bertolonii* DC. are different from this. Here, between the 3rd and 5th nodes, the number of innovations increases with the decrease in number of tubers. Concerning the culms of the garden *Ph. pratense* L. plants, between the first and second nodes, the number of tubers remarkably decreases, while that of the innovations increases to a slight extent (Fig. 3).

The tubers of the culms develop even at one-two node levels higher (Photograph 10) than the innovations. Here again, the culms of garden *Ph. bertolonii* DC. are different, since the innovations occurred at even four nodes higher levels (the highest level of tubers was the eighth node, while that of the innovations was the twelfth node; Fig. 3).

Summary

In all sizes, the diploid (2n = 14) *Phleum bertolonii* DC. is smaller than the hexaploid (2n = 42) *Phleum pratense* L. (NORDENSKIÖLD, 1945; HUBBARD, 1954; 1968). Qualitative and quantitative as well as informatory measurements were carried out with regard to the sizes of the epidermal cells of culms, spikelets and grains. In order to determine the number and length of the internodes and the number of tubers and innovations detailed measurements and comparisons were carried out on the culms of the two *Phleum* species, at internode and node levels.

The *Phleum bertolonii* DC. culms generally have more internodes than have the identical *Phleum pratense* L. culms. This difference is more significant in garden conditions where the *Phleum bertolonii* DC. culms spread in a decumbent position, their rhizome develop innovations to a remarkable extent and reproduce themselves vegetatively.

According to the examinations, the internode lengths differ significantly at every internode level between the two *Phleum* species grown in the original habitat. In the culms of the garden plants, the upper 5 internode lengths differ significantly when applying a great number of specimens (which means a method modified for reasons of principle), while the upper 2 only differ when using few and selected specimens.

In the lower third of the culms of both of the species, the lower part of the internodes, or alternatively the whole internodes thicken (tuber). The number of the tubers decreases rapidly upwards on the culms, except in the *Phleum bertolonii* DC. culms grown in the garden; with them, most of the tubers appear by and large on the middle internodes of the culms on the average.

With both species, innovations grow from the lower nodes of the culms, while from the upper nodes fewer grow. In the 33 *Phleum bertolonii* DC. culms grown in the garden, innovations grow on the average from every node, except the uppermost nodes.

In secondary, garden conditions, the tubers and innovations by nodes of the *Ph. bertolonii* DC. culms increase remarkably as against those of *Ph. pratense* L. grown under identical conditions. This is in connection with the greater number of internodes in *Ph. bertolonii* DC. and especially with its being inclined to reproduce itself vegetatively.

ACKNOWLEDGEMENTS

I wish to record my grateful thanks to József Újhelyi for the collected material for investigation and to acknowledge the valuable advice in this special field. My sincere thanks are due to Gábor Fekete for his useful advice in the statistical calculations; to Mrs. T. Lengyel for the carrying out of the significance calculations; and to Miss Jolán Muth for the microtechnical work and measurements.

REFERENCES

Arber, A. (1965): The Gramineae, a study of cereal, banboo, and grass. New York. 275—276.
Ascherson, P.—Graebner, P. (1898—1902): Synopsis der Mitteleuropäischer Flora. Leipzig. **2,** 140—142.
Baráth, Z.—ifj. Máthé, I.—Máthé, I. (1973): A Solanum genus Morella szekciójának vizsgálatairól I. Adatok a Solanum nigrum L. morfológiájához (On the investigations into the Morella section of the Solanum gene. I. Data to the morphology of Solanum nigrum L.). Bot. Közlem. **60,** 191—198.
Bordzilowskio, E.—Lavrenko, E. (red.) (1940): Flora RSS UCR (Flora Republicae Sovieticae Socialisticae Ucrainicae). Kioviae, **2,** 139—140.
Boros, Á. (1964): Rendszertani és kísérleti tanulmányok kultúrába vett vadontermő hazai takarmányfüvekkel (Taxonomical and experimental studies on cultivated and wild herb layer grasses after taking these into cultivation). Agrobot. **5,** 287—295.
Butcher, R. W. (1961): A New Illustrated British Flora. London, **2,** 1006—1007.
Clapham, A. R.—Tutin, T. G.—Warburg, E. F. (1959): Excursion Flora of the British Isles. Cambridge, 538.
Clapham, A. R.—Tutin, T. G.—Warburg, E. F. (1962): Flora of the British Isles. Cambridge. 1177—1178.
Dalla-Torre, K. W.—Sarnthein, L. G. (1906): Flora der Gefürsteten Grafschaft Tirol, des Landes Vorarlberg und des Fürstenthum Liechtenstein. Die Farn- und Blütenpflanzen. Innsbruck, **6,** 168—169.
Dandy, J. E. (prep.) (1958): List of British Vascular Plants. London, 166.
Darlington, C. D.—Wylie, A. P. (1955): Chromosome Atlas of Flowering Plants. London, 436.
De Candolle, A. P. (1813): Catalogus Plantarum Horti Botanici Monspeliensis. Monspelii, 151—152.
Degen, Á. (1936): Flora Velebitica. Budapest, **1,** 516.
Dostál, J. (1954): Klic K Uplné Kvetene ČSR. Praha, 1116.
Ehrendorfer, F. (1973): Liste der Gefässpflanzen Mitteleuropas. Stuttgart, 201.
Fedorov, A. A. (red.) (1974): Flora Partis Europaeae URSS. **1,** 243—246. Leningrad.
Fiori, A. (1896—1908): Flora Analitica D'Italia. **1,** 59. Padova.
Fiori, A. (1923—1925): Nuova Flora Analitica D'Italia. 90. Firenze.
Grossheim, A. (1928): Flora Kavkaza. 1, 70—72. Tiphlis.
Hajtman, B. (1968): Bevezetés a matematikai statisztikába (Introduction to mathematical statistics). 153—171, Budapest.

HEGI, G. (1927): Illustrierte Flora von Mittel-Europa. **1,** 211—216. München.
HERMANN, F. (1956): Flora von Nord- und Mitteleuropa. 102—103. Stuttgart.
HESS, H. E.—LANDOLT, E.—HIRZEL, R. (1967): Flora der Schweiz und angrenzender Gebiet. 275. Basel und Stuttgart.
HUBBARD, C. E. (1954): Grasses. 294—297. Harmondsworth, Middlesex.
HUBBARD, C. E. (1968): Grasses. 320—323. Harmondsworth, Middlesex.
JÁVORKA, S. (1925): Magyar Flóra (Flora Hungarica). **1,** 71. Budapest.
JORDANOV, D. (red.) (1963): Flora Reipublicae Popularis Bulgaricae, 282. Serdicae.
KOVÁTS, D. (1973): Szerveződési vizsgálatok a Lithospermum purpureo-coeruleum L. vegetatív rendszerén (Organizational investigations on the vegetative system of Lithospermum purpureo-coeruleum L.) Univ. Thesis. (Mscr.)
LID, J. (1952): Norsk Flora. 81. Oslo.
LINNÉ, C. (1759): Systema Naturae. ed. 10. 871. Holmiae impensis Laurentii Salvii.
MÁTHÉ, I.—HESZKY, L. (1972): A réti komócsin Phleum pratense L. (The timothy grass, Phleum pratense L.) Magyarország Kultúrflórája, **9,** pp. 91.
NORDENSKIÖLD, H. (1941): Cytological studies in triploid Phleum. Bot. Not. 12—32.
NORDENSKIÖLD, H. (1945): Cyto-genetic studies in the genus Phleum. Acta Agric. Suec. **1,** pp. 138.
ÖSTERGEN, G.—HENEEN, W. K. (1962): A squash technique for chromosome morphological studies. Hereditas, **48,** 332—341.
SAVULESCU, T.—POP, E. (red.) (1972): Flora Reipublicae Socialisticae Romania, **12,** 123.
SÁRKÁNY, S.—SZALAI, I. (1964): Növényszervezettani gyakorlatok (Phyto-organographical exercises). Növénytani praktikum I. (Botanical practice I.) Budapest, pp. 707.
SCHMEIL, O.—FITSCHEN, J. (1965): Flora von Deutschland. 497. Heidelberg.
SOÓ, R. (1973): A magyar flóra és vegetáció rendszertani-növényföldrajzi kézikönyve (Synopsis Systematico-Geobotanica Florae Vegetationisque Hungariae). **5,** 406—408. Budapest.
SOÓ, R.—JÁVORKA, S. (1951): A magyar növényvilág kézikönyve (Handbook of the Hungarian flora) **2,** 958—959, Budapest.
SOÓ, R.—KÁRPÁTI, Z. (1968): Növényhatározó (Plant identification handbook). Magyar Flóra. **2,** 781. Budapest.
STIEBER, J. (1972): Comparative analysis of wheat straw by the method of quantitative anatomy. Acta Agron. Acad. Sci. Hung. **21,** 345—357.
STIEBER, J.—PÁL, GY. (1957): The influence of various kinds of manuring on some histologic characteristics of rye-straw. Ann. Univ. Sci. Budapest.
STIEBER, J.—PÁL, GY. (1959): The influence of deep-manuring on some morphological and histological features in wheat-straw. Acta Agron. Acad. Sci. Hung. **9,** 425—450.
SVÁB, J. (1967): Biometriai módszerek a mezőgazdasági kutatásban (Biometric methods in agricultural research). Budapest. 32—75.
SZUJKÓ-LACZA, J.—FEKETE, G. (1973): Synphenological Changes in the Vegetation of a sub-Mediterranean Oak Forest (Orno-Quercetum). Ann. Hist.-nat. Mus. Nat. Hung. **65,** 127—146.
SZUJKÓ-LACZA, J.—SZŐCS, Z. (1976): The architecture and the quantitative investigation of some characteristics of anise, Pimpinella anisum L. Acta Bot. Acad. Sci. Hung. **21,** 443—450.
TROLL, W. (1937): Vergleichende Morphologie der höheren Pflanzen. **1,** 194—217, 702—817.
ÚJHELYI, J. (1938): Sesleria Studien. Index Horti Bot. **3,** 109—142.
ÚJHELYI, J. (1954): Újabb eljárás a szálaslevelű egyszikűek, különösen a Gramineae-család epidermisz szövettani vizsgálatához (Neues Verfahren zur epidermishistologischen Untersuchung der faserblättriger Monocotyledonen, insbesondere der Gramineae-Familie). Bot. Közlem. **45,** 227—230.
ÚJHELYI, J. (1959): Species Sesleriae generis novae. Fedd. Rep. **62,** 59—71.
ÚJHELYI, J. (1961—1974): Data to the Systematics of the Sections Bulbosae and Caespitosae of Genus Koeleria. I—XII. Ann. Hist.-nat. Mus. Nat. Hung. 53—66.
ÚJHELYI, J. (1972): Evolutionary problems of the European Koelerias. Symp. Biol. Hung. **12,** 163—176.
VISIANI, R. (1842): Flora Dalmatica, sive Enumeratio Stripium Vascularium. **1,** 63, **3,** 338. Lipsiae.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1—2), pp. 127—147 (1976)

THE MELOCACTUS SPECIES OF CUBA

By

Z. MÉSZÁROS

RESEARCH INSTITUTE FOR PLANT PROTECTION, BUDAPEST

(Received November 10, 1975)

The author collected cacti in Cuba in 1974—1975. As a result of his collecting activities he describes five new *Melocactus* species (*M. jakusii* sp. n., *borhidii* sp. n., *evae* sp. n., *radoczii* sp. n., *nagyii* sp. n.), a new subspecies (*M. acunai* León ssp. *lagunaensis* ssp. n.) and a new variety (*M. acunai* León var. *flavispinus* var. n.). On the basis of the new species and of the four known *Melocactus* species (*M. harlowii* Br. et Rose, *acunai* León, *guitartii* León, *matanzanus* León), the author submits also a monographic elaboration of the Cuban *Melocactus* species.

The first *Melocactus* species of Cuba *(Melocactus harlowii)* was described by BRITTON and ROSE, from the province Oriente ("Coastal cliffs, U.S. Naval Station" — Guantánamo), in 1912. More than twenty years passed before three other *Melocactus* species were described by LEÓN (1934) from Cuba, namely *Melocactus acunai* (Punta Maisi, Oriente), *M. guitartii* (Sierra de Jatibonico del Sur, on the outskirts of Camagüey and Las Villas, and *M. matanzanus* (Cuabal de las Tres Ceibas, Matanzas).

In the same work, LEÓN reported another locality of *M. harlowii*, namely Imias on the southern coast. Referring to a personal communication by BRITTON, he mentioned a further site called Ensenada de Mora near Cabo Cruz in the coastal section.

I had opportunities on three occasions in Oriente to collecting cacti with the kind assistance of the Hungarian geologist expedition. The first occasion was between December 29, 1974 and January 19, 1975, when I was with Elemér NAGY, between Guantánamo and Surgidero de Macambo, and also Pilón and El Macio; the second occasion was between March 6 and 10, 1975, when I was with Péter JAKUS between Tortuguilla and Playitas de Cajobabo, as well as in the Sierra Cerro Galano; the third occasion was between May 13 and 17, 1975, when I was with Gyula RADÓCZ, between Tortuguilla and Punta Caleta, as well as in the areas of Sierra de Purial and Sierra de Baracoa. In addition to these joint collecting activities, Elemér NAGY collected cacti for me on the outskirts of Guantánamo, and of Punta Maisi, in April, 1975; Gyula RADÓCZ collected Melocacti for me between Pilón and Santiago de Cuba on the southern coast, in May, 1975. Our collecting tours resulted in species new for science, in addition to the collection of species already known.

We also succeeded in collecting two *Melocactus* species (*M. matanzanus* León and *M. guitartii* León) in localities outside of the territory of Oriente, between March and May, 1975.

Difficulties arose when the nominate subspecies of *M. harlowii* was to be determined. According to our collecting experience, closely related yet district species grow in discontinuous areas on the southern coast. The population found on the so-called "Macambo terrace", west from the village Imias, seems to come nearest BRITTON and ROSE's description. Since the original description is rather taciturn, and the type-locality of the species (Guantánamo) is not accessible owing to strategic reasons, it seemed proper to give a more detailed description of the morphological characteristics. This solution seemed the more appropriate as LEÓN (l. c.) mentioned the village Imias as the second known locality of *M. harlowii*.

The southern coast of Oriente is remarkably rich in *Melocactus* species. On the southern coast and in the dry valleys and the serpentine areas intruding for some kilometres in many places towards the north numerous *Melocactus* populations grow which have separated partly into distinct species partly into subspecies. I am convinced that this coast section has other *Melocactus* species and infraspecific forms still in store. My opinion in this respect agrees with that of J. RIHA (1971), who also collected Melocacti in the area. However, a more accurate survey of the areas is hardly conceivable without the help of the Cuban authorities.

The type-specimens of the new species and subspecies have been deposited in the National Herbarium of Cuba (Santiago de las Vegas, La Habana, Cuba).

A survey of the Melocactus species of Cuba

Series: *Matanzanus*

1. *M. matanzanus* León — Cuabal de las Tres Ceibas, north of Corral Nuevo (Matanzas), on serpentine grounds.

Series: *Guitartii*

2. *M. guitartii* León — Sierra de Jatibonico del Sur, to the north-west of Arroyo Bermejo, in the direction of Boca Chica, in the territory of Finca Dagamal and Finca Juan López (Camagüey), on pyroxene andesite rocks.
3. *M. jakusii* sp. nova — Sierra Cerro Galano, to the east of Holguin (Oriente), on serpentine rocks.

Series: *Harlowii*

4. *M. harlowii* agg.

4.a. *M. harlowii* Br. et Rose — Surgidero de Macambo, to the west of Imias (Oriente), on coastal limestone terraces.

4.b. *M. borhidii* sp. nova — between Tortuguilla and Baitiquiri, to the east of the mouth of Rio Yateras (Oriente), on coastal limestone terraces.

4.c. *M. evae* sp. nova — on the western side of Guantánamo Bay, to the south-west of Caimanera (Oriente), on single conglomerations arising from sandstone.

5. *M. radoczii* sp. nova — Sierra de Baracoa, to the north of La Tinta, on the outskirts of Guajimero (Oriente), on serpentine substrate.

6. *M. acunai* León

M. acunai ssp. *acunai* var. *acunai* — south-west and west from Punta Maisi (the easternmost point of Cuba) up to Imias (Oriente), on coastal limestone terraces.

— — var. *flavispinus* var. nova — in the former territory, around the mouth of the Rio Tacre, on coastal limestone terraces.

M. acunai ssp. *lagunaensis* ssp. nova — Sierra de Purial, to the north and north-west of Cajobabo, on the western side of Rio Jojo, to the north and north-west of Laguna de Jojo, on local serpentine extrusions.

7. *M. nagyii* sp. nova — between La Mota and Ocujal, in the coastal belt lying along the southern side of the Sierra Maestra (Oriente), on volcanic rocks and cliff walls.

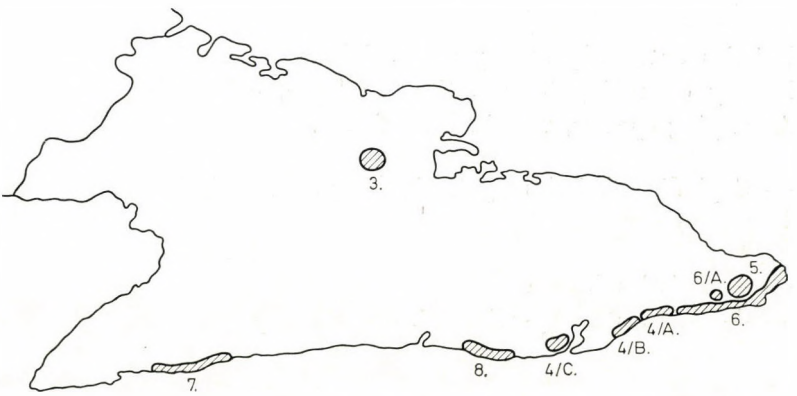


Fig. 1. Melocactus species of Oriente. 3 = *M. jakusii*; 4/A = *M. harlowii*; 4/B = *M. borhidii*; 4/C = *M. evae*; 5 = *M. radoczi*; 6 = *M. acunai*; 6/A = *M. acunai* ssp. *lagunaense*; 7 = *M. nagyi*; 8 = *Melocactus* sp.?

Identification key to the Melocactus species of Cuba

1.a. Plants of small or medium stature; flattened, globulose, or their height not much differing from their diameter; not ramifying. Radial and central bristles readily distinguishable, radial bristles curving towards body, central ones protruding or curving towards body **2**

b. Plants of various sizes, approximately columellar, their height always greater than their diameter (without cephalium). Mature individuals rather inclined to ramification. Radial and central bristles hardly distinguishable, radial bristles not or hardly curving towards body .. **4**

2.a. Stature small, flattened, globose; maximum diameter 10 cm; eight ribs. Bristles not meeting, body of plant freely seen among its short grey bristles, all bristles curving towards body, and even longest bristle not reaching 2 cm

M. matanzanus León

b. Stature medium, diameter 10—12 cm, height less or hardly more (without cephalium); 11—13 ribs. Radial bristles bending towards body, central bristles protruding and extending to a length of more than 2 cm **3**

3.a. Flattened, globose, height less than its diameter (without cephalium). Bristles dense, its two strong central bristles exceeding 3 cm

M. guitartii León

b. Globose, broadest in its lower third, height identical with diameter or slightly higher (without cephalium). Bristles sparser, one or two central bristles generally 2—2.5 cm, or at most 3 cm

M. jakusii sp. nova

4.a. Bristles extremely strong and thick; central bristles exceeding 4 cm, basally exceeding 3 mm. Stature large, columellar, often ramifying. A varying species, rich in local forms.

M. acunai León

— Cephalium-bristles rigid, regularly arranged, fruit elongated obovate

M. acunai ssp. **acunai** León

— — Bristles brown — — var. **acunai**

— — Bristles honey-coloured, occasionally base of bristles brownish

— — var. **flavispinus** var. nova

— Cephalium-bristles soft, irregularly arranged, fruit short, widely obovate

M. acunai ssp. **lagunaensis** ssp. nova

b. Bristles thinner, if subuliform, their length not reaching 4 cm, basally not thicker than 3 mm **5**

5.a. Bristles rigid, non-elastic. Cephalium higher than wide; bristles of cephalium loose, soft, more or less irregularly placed, dull. Columellar plants of large stature, often ramifying. A varying species, rich in local forms

M. nagyii sp. nova

b. Bristles thinner, more or less elastic. Cephalium discoid, height smaller than wide (very rarely old individuals elongated). Bristles of cephalium hard, strong, erect, regularly arranged and generally of a vivid colouration **6**

6.a. Stature large, globose or elongately ovate (diameter 12—16 cm, height 11—18 cm, without cephalium)

M. harlowii Br. et Rose

— Fruit deep pinkish purpureous

—— f. **harlowii**

— Fruit white

—— f. **candidus**

b. Stature smaller in diameter (in fully grown state), generally less than 10 cm, exceptionally 10—12 cm **7**

7.a. Slender, columellar, diameter of fully-grown individual not exceeding 6—8 cm, height at least twice greater; mature plant with 5—8 strikingly lanuginose areolar rows below cephalium

M. borhidii sp. nova

b. Stature smaller elongately oval, diameter 8—10 (—12) cm, height always greater than diameter, but not one and a half or twice higher; areolar rows below cephalium hardly lanuginose **8**

8.a. Densely ribbed (13 ribs). Central bristles erect or slightly upcurving. Bristles of cephalium dull brown, sparsely spaced, diameter of full-blown flower greater than 20 mm

M. evae sp. nova

b. Sparsely ribbed (10 ribs). Central bristles definitely upcurving. Bristles of cephalium bright rufous, denser. Diameter of full-blown flower 12—14 mm or less

M. radoczii sp. nova

The Melocactus species of the Province Oriente

The southern coast of the Province Oriente is the poorest in precipitation in Cuba. The annual quantity of precipitation is generally below 1000 mm, but occasionally below 800 mm (Atlas Nacional Cuba, La Habana, 1970). According to the more detailed climate analyses by Attila Borhidi, at certain places the precipitation is essentially less than that: between 300—500 mm (Borhidi, 1974). With the exception of one species, all *Melocactus* species of Oriente grow in this area.

The exceptional species is *M. jakusii* sp. nova, growing on the serpentine rocks of Sierra Cerro Galano, in NW Oriente. (The two species which grow outside the boundaries of Oriente, viz. *M. matanzanus* León and *M. guitartii* León, are to be found more inland, in similar conditions, on serpentine or on pyroxene andesite.) Concerning its morphology *M. jakusii* sp. nova stands close to *M. guitartii* León, which grows in the Province Camagüey, and it can be relegated to the same Series. *M. jakusii* is a transitory form between certain forms of *M. guitartii* and *M. nagyii* sp. nova of SW Oriente.

The westernmost *Melocactus* species of the southern coast is *M. nagyii* sp. nova, inhabiting a section of some 40 km in the lower regions of the southern rock walls of the Sierra Maestra, between La Mota and Ocujal. This species produces several local forms, more or less in contact with one another. The type-specimens were collected between La Mota and El Macio on andesite tufa-tufite rocks, about 10—20 m a.s.l. in January, 1975 (leg. Z. MÉSZÁROS and E. NAGY). Additional specimens were collected by GY. RADÓCZ, in May, 1975. These originate from the following localities:

1. Between El Macio and the mouth of Rio Macio, on andesite porphyrine rocks, at about 50 m a.s.l. Plants of rather small stature, conical, vivid green, with basal shoots.

2. Between the mouth of Rio Macio and El Macho, on andesite tufa-tufite, at 20—50 m a.s.l. More yellowish, conical plants.

3. East of El Macho, on diorite rocks, at a distance of some 100 m from the coast, about 50 m a.s.l. Medium-sized plants.

4. Between Magdelena and La Plata, on andesite tufa-tufite, on slanting, barren cliff faces, along the clefts, about 10—20 m from the coast, about 50—100 m a.s.l. More vividly shooting plants.

5. About 1 km eastward from the former locality, at the meeting of diorite and tufa, about 100 m from the coast, about 20—50 m a.s.l. This population is rather heterogeneous, with columellar to stout specimens.

6. At a distance of a few hundred meters to the west of the mouth of Rio La Plata, on andesite tufa-tufite, at about 50 m a.s.l. The plants growing there are of the largest stature, elongated columellar (one old plant is 38 cm high and 13 cm in diameter). This population is probably identical with RIHA's *Melocactus* labelled OL-21, of a high stature.

7. To the east of La Plata, on a diorite vein, about 50 m a.s.l. Elongated, globose plants with extremely robust bristles.

8. Between Cuevas del Turquino and Potrerillo, on diorite, at about 30—50 m a.s.l. The plants are of small stature, growing in the half shade of trees and shrubs, apparently the easternmost locality of the species. Eastwards to Santiago de Cuba (that is, along the great continuous block of the Sierra Maestra) no more *Melocactus* occurence was found.

An interesting datum should be mentioned here. In one of the localities mentioned, in site 5, GY. RADÓCZ observed among the characteristic forms of *Melocactus nagyii* some specimens of a strikingly different stature. He even collected two of them. These are very slender, columellar plants with fine bristles; unfortunately, at that time none of them had a cephalium as yet. Presumably there lives in the higher regions of the Sierra Maestra, above the habitat belt of *M. nagyii*, also another distinct species, and RADÓCZ accidentally collected exemplars of this species. However, to clarify this question would be a task very difficult to accomplish technically.

Between Santiago de Cuba and the Bay of Guantánamo, the Sierra

Maestra is a contiguous block with a name of its own: Sierra de la Gran Piedra. We have data on *Melocacti* from two parts of the block. In the western end of the area, between Siboney and El Morro (nearer to Siboney), we saw *Melocacti* on the perpendicular cliff walls. Lack of time and technical conditions prevented us from collecting specimens, and to adjudge specificity by binoculars would, especially in this case, have been unfeasible. In the eastern end of the block, in the valley of Rio Sigua, another *Melocactus* population occurs, labelled OL—17 by RIHA; he considers it a variety of *M. harlowii*. I was unable to visit this site, but E. NAGY collected a few specimens in June, 1975, around the mouth of Rio Sigua, on the coastal limestone terraces. These specimens seem to confirm RIHA's assumptions. The *Melocacti* growing in the area of the Sierra de la Gran Piedra require further study.

Around the Bay of Guantánamo and to the east of it, there live distinct *Melocactus* populations representing morphologically and geographically distinct species relegable to *M. harlowii* agg. BRITTON and ROSE described *M. harlowii* from the coast of Guantánamo. This area is not accessible owing to military reasons. East of the bay to Imias, the *Melocactus* species are closely related to *M. harlowii*. Among them, the population growing mainly on the first coastal limestone terrace (Surgidero de Macambo) between Imias and San Antonio del Sur corresponds most to BRITTON and ROSE's original description. Assuming this as the lectotype of the species, the individuals collected there serve as a basis for the redescription.

To the west from the Bay of Guantánamo, in a direction towards the south-west from Caimanera, *Melocactus evae* sp. nova grows on a gravel-conglomerate field. A special feature of this relatively small-sized species is that it has the largest flower (the diameter of the full-blown flower is 22—25 mm) of all of its Cubanese congeners.

To the east of the Bay, on the eastern side of the Rio Yateras, from the village of Tortuguilla to about the line of Baitiquiri, *Melocactus borhidii* sp. nova grows near the coast. This slender columellar *Melocactus* species occurs in large numbers on the barren rocks of the first, second, and sporadically on the third, limestone terrace.

To the east of the line of Imias and in a long narrow strip up to the eastern end of the island, grows *Melocactus acunai* León. This large and rather varying species was described by LEÓN from the area of Punta Maisi, the eastern end of Cuba. The species is not particular to substrate, occurring almost everywhere within its range, in sites without a closed vegetation. We found a population also in a half-shaded area: large-sized *acunai* specimens grew among trees and shrubs on magmatic rock (diorite-porphyry) immediately near Cajobabo. Within the range of the species, the variety with yellow bristles, var. *flavispinus* var. nova, grows on limestone terraces on the two sides of the mouth of Rio Tacre.

To N—NW of Cajobabo, on the western side of the Rio Jojo (N—NW from the Laguna de Jojo), ssp. *lagunaensis* ssp. nova, a morphologically well distinguishable subspecies of *M. acunai*, grows on local serpentine extrusions.

To the north of the long, narrow east-western zone of range of the former species, *Melocactus radoczii* sp. nova grows on serpentine rocks in the area of Sierra Purial. This small-sized species with fine spines grows in colonies scattered in a relatively small area, around the valley of Rio Jauco, to the north of La Tinta, and in the environs of Guajimero. Its probable northern confines is the valley of Rio Yumuri, and to the west the block of Loma La Farola.

Description of new taxa

Melocactus jakusii Mészáros sp. nova

Globose by columellar, widest in its lower third. Always occurring singly, even old plants not ramifying. About as high as or slightly higher than wide. Diameter 9—12.5 cm, height 10—14 cm (without cephalium). 11—13 angulate ribs with 6—7 areoles per 10 cm.

Bristles robust, rigid, somewhat sparse, brownish corneous, young bristles vivid reddish brown, apically slightly darker; 1—2 central bristles porrect or slightly upcurving, about 2—2.5 cm long, with 8—10 radial bristles about 1—2.5 cm long, lowermost one longest, uppermost ones shortest.

Cephalium depressed, discoidal, 1.5—3.5 cm high, 4—5 cm wide. Cephalium bristles pale reddish brown, soft, entangled, projecting about 6—10 mm from a greyish white lanuginosity.

Flower deep purplish, 10—11 mm wide, protruding from the short cephalium bristles. Stigma 5—6-lobulate, hardly paler than petals. Fruit unknown. Seeds black, shiny, submuricate.

Type: on serpentine rocks, SW slopes of the Sierra Cerro Galano, E of Holguin, NW Oriente, Cuba. Leg.: Z. MÉSZÁROS and P. JAKUS, March, 1975.

Dedicated to its discoverer, Péter JAKUS, member of the Hungarian geologist expedition.

Caulis subgloboso-ovatus, in parte tertia inferiore latissimus, semper simplex, nunquam ramificatus, latitudine aequilongus vel paullo longior, 10—14 cm altus (sine cephalio), in diam. 9—12.5. Costae 11—13 angulatae emergentes, areolae 1.4—1.6 cm longe distantes (6—7 areolae per 10 cm). Spinae robustae, rigidae, subfusco-corneae, juveniles rufescentes vel castaneae, apice obscuriores, centrales 1—2, rectae vel paullo sursum curvatae, 2—2.5 cm longeae, radiales 8—10, 1—2.5 cm longae, infima longissima, supremae brevissimae. Cephalium depressum discoideum, 1.5—3.5 cm altu, in diam. 4—5 cm. Setulae cephalii gilvo-ferrugineae, molliter curvatae, 6—10 mm longe exsertae. Flores obscure-purpurei, 10—11 mm in diam., e setulis cephalii exserti. Stylus apice 5—6 lobulatus sepalis vix muricata.

Typus: Cuba, Provincia Oriente, Sierra Cerro Galano, in declivibus aridis serpentinosis, meridionali-occidentalibus pr. opp. Holguin. Leg.: Z. MÉSZÁROS et P. JAKUS, March 1975.

Melocactus borhidii Mészáros sp. nova

Slender, columellar, diameter of fully grown specimen 6—8 cm. Generally 15—20 cm high, but some old individuals even 22—29 cm high (without cephalium); 11—12 sharp, protruding, rather narrow ribs. Old individuals somtimes apically proliferating, sprouts globose, slightly elongated, 3—6 in number, Bristles relatively acicular, flexible. Radial and central bristles hardly differentiated, 2—4 central bristles 20—25 mm long, 10—15 (or less) radial bristles 10—15 cm long. Bristles as a whole slightly upcurving, whitish corneous, their tips reddish, fresh bristles entirely reddish. Distance between areoles smaller than 1 cm; 11—14 areoles per 10 cm; 5—8 rows of areolae below cephalium of fully grown plants whitish, lanuginose.

Cephalium slightly flattened, cylindrical, 2.5—3.5 cm high, 3—4.5 cm wide. Bristles of cephalium porrect, rigid, thin, aciculate, vivid fox-red and protruding about 10—12 mm from the white lanuginosity.

Flower small, open blossom shorter than bristles of cephalium, sometimes just reaching their length; 7—9 mm wide. Petals deep pinkish purpureous, stamen and 5—6-lobulate stigma pale pink. Fruit obovate, 8—9 mm thick, 17—19 mm long. Seeds dark-brown, globose, shiny, slightly muricate.

Type: at 10—20 m height above sea level near coast, on the second and third limestone terraces on the outskirts of Tortuguilla, E of the mouth of Rio Yateras, on the southern side of the Sierra Purial, coast of the Province Oriente, Cuba. Leg.: Z. MÉSZÁROS and E. NAGY, January, 1975.

Dedicated to Attila BORHIDI, Hungarian botanist working in Cuba.

Caulis columnaris elongatus, cylindricus (in statu bene evoluto), 7—8 cm crassus et 15—20 longus, rare usque ad 22—30 cm altus, apice rare ramigerus, rami 3—6 globosi, subglobosi v. brevissime ovati. Costae caulinares 11—12. Spinae aciculares, tenues, flexuosae, radiales 10—15, usque ad 10—15 mm longae, centrales 2—4, usque ad 20—25 mm longae, leviter sursum curvatae, albo-corneae, apice purpurascentes, novellae per totam longitudinem roseae. Areoleae dense dispositae, 0.7—0.9 cm longe distantes (11—14 areoleae per 10 cm), superiores in 5—8 lineis (sub cephalio) dense albolanatae. Cephalium leviter depressum discoideum, 2.5—3.5 cm longum, in diam. 3—4.5. Setulae cephalii rectae, rigidae, tenuiter aciculiformes, rubiginosae, ex lana cephalii 10—12 mm longe exsertae. Flores parvi, 7—9 mm in diam., in statu aperto setulis cephalii breviores. Petala obscure roseo-purpurea, antherae et stylus apice 5—6 lobulatus pallude roseae. Fructus obovatus, roseo-albicans, 17—19 mm longus et 8—9 mm crassus. Semina suborbicularia, lucida, fusca, leviter muricata.

Typus: Cuba, Provincia Oriente. In saxosis calcareis litoralibus, in orientem de bucca rivi Yateras, pr. pag. Tortuguilla, supra scalam secundam et terciteram, in altitudine 10—20 m s.m. Leg.: Z. MÉSZÁROS et E. NAGY, January 1975.

Melocactus evae Mészáros sp. nova

Slender, columellar, of small stature, diameter of fully-grown plant 6—8 (—9) cm, height (without cephalium) 8—12 cm. Old specimens occasionally ramifying, reaching a height of 18—20 cm. 13 sharp, protruding ribs.

Distance between areolae about 1 cm; about 9—12 areolae per 10 cm; upper areolae slightly lanuginose. Bristles relatively acicular, flexible, corneous, apical two-thirds of young bristles brownish. 1—3 central bristles 25—30 cm long, 12—14 radial bristles 10—20 mm long.

Cephalium slightly flattened, 2.5—3 cm high, 4—5 cm wide. Bristles of cephalium pale brown, sparsely spaced and protruding about 4—6 mm from yellowish-white lanuginosity.

Flower large, 20—25 mm wide, deep pink. Petals in several rows, external ones recurving. Style 5-lobulate, slightly lighter pinkish. Fruit obovate, 18—20 mm long and 9—11 mm thick, deep pink, lighter basad. Seeds black, muricate.

Type: on gravel conglomeration SW of Caimanera, on the western side of Guantánamo Bay, Province Oriente. Leg.: E. NAGY, April, 1975.

I dedicate this slender, large-flowered *Melocactus* species to my wife, without whose assistence this study could not have been accomplished.

Caulis columnaris elongatus, statura parva, 6—8 (—9) cm crassus, 8—12 cm longus, sine cephalio. In statu evoluto raro ramificatus, usque ad 18—20 cm longus. Costae 13, acutae, exstantes. Distantia areolarum ferme 1 cm, 9—12 areolae per 10 cm, superiores parumper lanatae. Spinae aciculares, relative tenues, flexuosae, coloris cornei, novellae in parte superiore subfuscae. Centrales 1—3, 25—30 mm longae, radiales 12—14, long. 10—20 mm. Cephalium leviter depressum, 2.5—3 cm altum, 4—5 cm crassum. Setulae cephalii luride subfuscae, longe distantes, e lana helochroleuca 4—6 mm longe exstantes. Flores magni, diam. 22—25 mm, obscure rosei. Petala in pluribus ordinibus collocata, externa reflexa. Stylus 5 lobulatus, subroseus. Fructus obovatus, 18—20 mm longus, 9—11 m crassus, obscure roseus, inferne albicans. Semina nigra, muricata.

Typus: Cuba, Provincia Oriente, in regione occidentali sinus Guantanemensis, prope Caimanera, in conglomerato glareoso. Leg.: E. NAGY, April, 1975.

Melocactus radoczii Mészáros sp. nova

Barrel-shaped, of relatively small stature, widest medially. Diameter of fully-grown plant 9—12 cm, height 11—13 cm (without cephalium). Old plants frequently ramifying, branches often as high as 20 cm. Ten angular protruding ribs; densely areolated, 11—12 areoles per 10 cm.

Bristles finely acicular, as a whole upcurving, yellow, young bristles fox-red. 3—4 central bristles 20—25 mm long, 14—16 radial bristles 10—25mm long.

Cephalium depressed, discoidal, 3 cm high, 4.5—5.5 wide. Bristles of cephalium vivid fox-red, in a regular pattern, protruding from yellowish-white lanuginosity to a length of 6—8 mm.

Flower 10—12 mm wide, intense pink; stamous and 6-lobulate style lighter pink. Fruit obovate, 14—21 mm long and 7—10 mm wide, deep pink, basally sometimes lighter. Seeds black, heavily muricated.

Type: on serpentine rocks on the outskirts of Guajimero, north of La Tinta, Sierra de Baracoa, Province Oriente. Leg.: Z. MÉSZÁROS and GY. RADÓCZ, May, 1975.

Dedicated to Gyula RADÓCZ, member of the Hungarian geologist expedition.

Caulis relative parvus, dolio similis, in parte media latissimus. Diameter in statu evoluto 9—12 cm, altitudo sine cephalio 11—13 cm. Caules Veterea saepe ramificati et usque ad 20 cm longi. Costae 10, acutae, exstantes, dense areolatae, per 10 cm 11—12 areolas, Spinae aciculares, leviter sursum curvatae, subflavae, novellae rufae. Centrales 3—4, long. 20—25 mm, radiales 14—16, long. 10—25 mm. Cephalium depressum, discoideum, alt. 2.5—3 cm, diam. 4.5—5.5 cm. Setulae cephalii acriter rufae, ordinatae, e lana helvola 6—8 mm longe erectae. Flores parvi, 10—12 mm in diam., intense rosae, antherae et stylus apice 5—6 lobulatus pallide roseae. Fructus obovatus, obscure roseus, long. 14—21 mm, diam. 7—10 mm, inferne nonnunquam albicans. Semina nigra, manifeste muricata.

Typus: Cuba, Provincia Oriente, Sierra de Baracoa, in septemtriones a La Tinta, circum vicum Guajimero, in saxis serpentinosis. Leg.: Z. MÉSZÁROS et GY. RADÓCZ, May, 1975.

Melocactus nagyii Mészáros sp. nova

Globose, slightly elongated, fully-grown specimen 10—16 cm wide, 12—18 cm high (without cephalium). 10—12 acuto-angulose, emergent, mostly straightly decurrent ribs, sometimes slightly curved. Mature plants sometimes apically ramifying, shoots globose, 4—7 in number. Distances between areolae rather varying, 7—12 areolae per 10 cm; bristles robust, subulate, 9—15 in number. Radial and central bristles hardly differentiated, 3—4 central spines 25—38 mm long, radial ones 15—30 mm long. Bristles yellowish or brownish corneous, fresh spines more brownish.

Cephalium cylindrical, slightly higher than wide (4.5—6.5 cm high, 4.5—6 cm wide). Cephalium of old plants often elongated. Bristles arcuate, soft, pale brownish, protruding about 5—8 mm from yellowish-white lanuginosity.

Flower emergents from bristles of cephalium, open blossom projecting over bristles. Petals pinkish purpureous, stamens and 5—6-lobulate stigma pale pink. Diameter of fully open flower 14—16 mm. Fruit elongated obovate, 20—22 mm long and 5—6 mm wide, deep rosaceous, basally white. Seeds black, heavily muricate.

Type: near the coast between La Mota and El Macio, on the steep southern rock walls of the Sierra Maestra, southern coast of Cuba. Leg.: Z. MÉSZÁROS and E. NAGY, January, 1975.

Dedicated to its discoverer, Elemér NAGY, head of the Hungarian geologist expedition.

Caulis globosus, leviter oblongatus, diam. 10—16 cm, sine cephalio 12—18 cm altus (in statu perfecte evoluto), costae 10—12 cm, acutangulosae, emergentes, plerumque rectae, rariter leviter cuvatae. Caulis apice raro ramosus, rami 4—7 globosi. Areolae varie distantes,

7—12 areolae per 10 cm. Spinae 9—15 robustae, subulatae, flavido- vel subfusco-corneae, novae brunnescentes, radiales centralibus paullo differentes, radiales 15—30 mm largae, centrales 3—4, 25—38 mm longae. Cephalium cylindricum latitudine paullo longius (4.5—6.5 cm longum, 4.5—6 cm latum). Setulae cephalii cuvatae, molles, e lana lutescenti 5—8 mm longe exsertae. Flos apertus, 12—14 mm in diam., setulos cephalii parum superans, petala roseo-purpurea, antherae et stylus 5—6 lobulatus pallide roseae. Fructus lineari-obovatus, 20 mm longus et 5 mm latus, intense roseus, inferne albicans. Semina nigra suborbicularia, manifeste muricata.

Typus: Cuba, Provincia Oriente. In rupibus vulcanici litoralibus declivium meridionalium montium Sierra Maestra, inter pag. La Mota et El Macio, 10—20 m supra mare. Leg.: Z. MÉSZÁROS et E. NAGY, January, 1975.

Melocactus acunai León ssp. **lagunaensis** Mészáros ssp. nova

Robust, columellar, ramifying, branches of old plant occasionally again ramifying. Entire plant 11—13 cm wide, 13—16 cm high (without cephalium). 10—11 angulate, emergent ribs, 6—7 areolae per 10 cm. Multiply ramifying old plants even 40—55 cm high and 20—22 cm wide. Bristles not differing from those of ssp. acunai. Cephalium cylindrical, elongated in old plants, as high as 15 cm and as wide as 7.5 cm. Bristles of cephalium soft, disarranged, reddish-brown or pale brown, protruding some 5—8 mm from greyish-white lanuginosity.

Flower pale pink, 8—10 mm wide. Stigma 6—8-lobulate, light pink. Fruit short, wide, obovate, 8—9 mm thick, 12—14 mm long, deep pink, basally whitish. Seeds dark brown, slightly muricate.

Type: on local serpentine extrusions on the NW side of the Laguna de Jojo, NW of Cajobabo, in the area of Sierra de Purial, Province Oriente, Cuba. Leg.: Z. MÉSZÁROS and P. JAKUS, March, 1975.

Caulis robustus columellaris, saepe ramificatus, rami in statu evoluto non raro iterum ramificati. Caulis in diam. 11—13 cm, 13—16 cm longus (sine cephalio). Costae 10—11 emergentes, angulateae, areolae 6—7 per 10 cm. Caules evoluti pluries ramificati usque ad 40—55 cm longi et 20—22 cm in diam. Spinae uti apud ssp. acunai. Cephalium cylindricum, elongatum, long. maxima 15 cm, diam. 7.5 cm. Setulae cephalii molles, irregulariter dispositae, ferrugineae vel pallide subfuscae, e lana albida 5—8 mm exsertae. Flos pallide roseus, 8—10 mm in diam., stylus 6—8 lobulatus, gilvo roseus. Fructus brevis, late obovatus, 8—9 mm crassus, 12—14 mm longus, intense roseus, inferne albicans. Semina fusca, submuricata.

Typus: Cuba, Provincia Oriente, Sierra de Purial, in regione boreo-occidentale, in clivo Lagunae de Jojo serpentinoso. Leg.: Z. MÉSZÁROS et P. JAKUS, March, 1975.

Melocactus acunai León var. **flavispinus** Mészáros var. nova

Bristles entirely dark yellow, or dark yellow and basally brown.

The variety grows within the range of the nominate form, on the coastal limestone rocks around the mouth of Rio Tacre.

Spinae aut per totam longitudinem flavae, aut in parte superiore flavae, inferiore subfuscae. Haec varietas habitat intra territorium subspeciei nominalis, in saxis calcareis litoralibus, apud buccam rivi Tacre.

Melocactus harlowii Britton et Rose (redescription)

Globose, slightly elongated, fully-grown specimen 11—16 cm wide, 11—18 cm high (without cephalium). 10—12 angular, emergent, straightly decurrent ribs. Old plants rarely ramifying. Areolae more than 1 cm apart 8—10 areolae per 10 cm. Bristles thick, acicular, about 1 mm thick, corneous; fresh bristles reddish brown, apically darker. Radial and central bristles hardly differentiated, 2—4 central bristles 30—38 mm long, 8—10 (—12) radial ones 15—28 mm long. Cephalium discoid, depresso-globose; shorter than wide (2—2.5 cm high, 3—5 cm wide); sometimes cephalium of very old specimens elongated. Bristles of cephalium rigid, straight, protruding from greyish-white lanuginosity to about 10 mm, reddish brown or dark brown.

Flower protruding from bristles of cephalium, fully open blossom projecting over bristles. Petals deep pinkish purple, stigma 5—7-lobulate, pale rosaceous. Diameter of fully open flower 10—12 mm. Fruit obovate, 9—11 mm thick, 20—22 mm long; deep pinkish purple (f. *harlowii*) or bright white (f. *candida*). Seeds black, weakly muricate.

Lectotype: immediately on the coast at a height of 4—5 m, on the surface of the first limestone terrace, in the area of Surgidero de Macambo (between San Antonio del Sur and Imias), southern coast of Province Oriente Cuba.

Leg.: Z. MÉSZÁROS and E. NAGY, January, 1975.

Fig. 2. Melocactus matanzanus León

Fig. 3. Melocactus matanzanus León

Fig. 4. Melocactus guitartii León

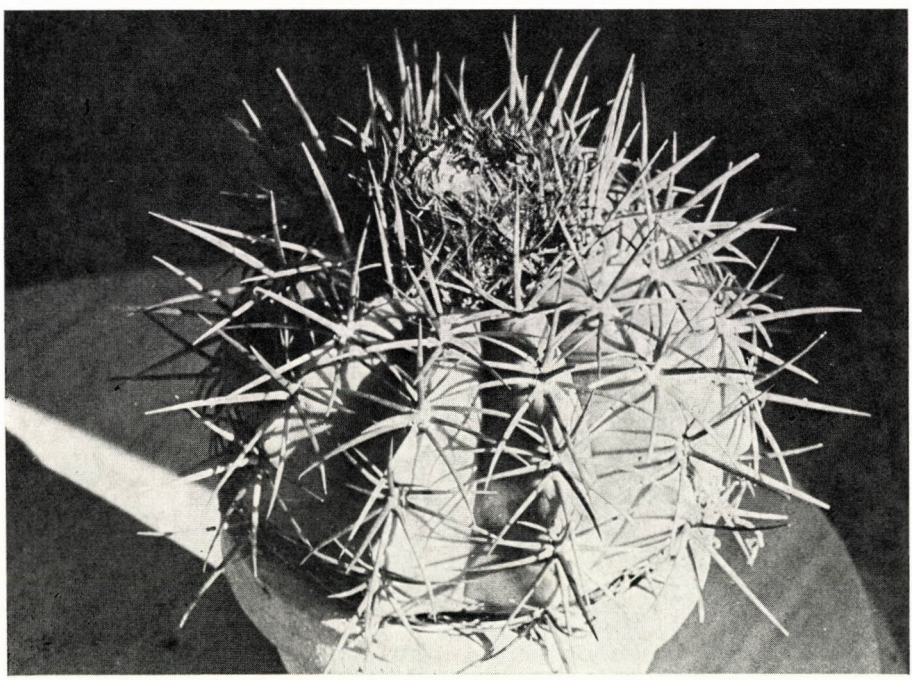


Fig. 5. Melocactus guitartii León

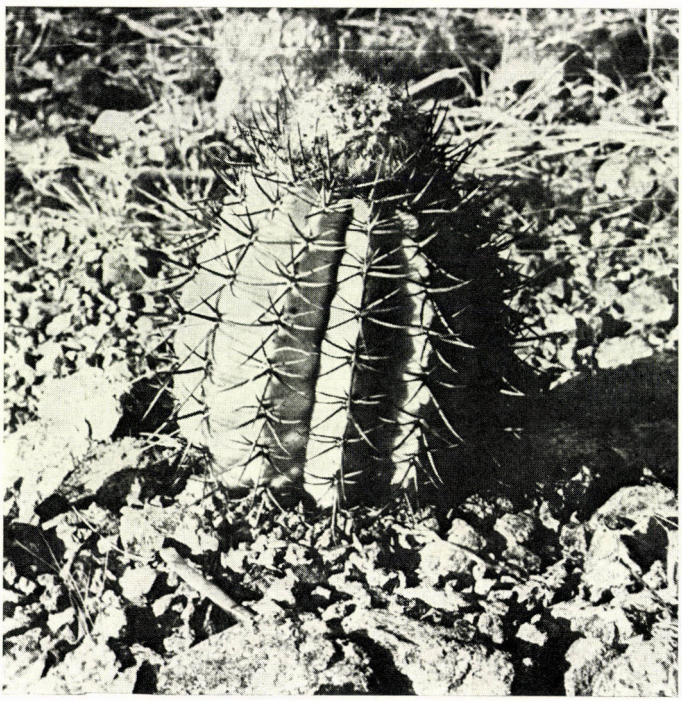


Fig. 6. Melocactus jakusii Mészáros sp. nova

Fig. 7. Melocactus harlowii Britton et Rose

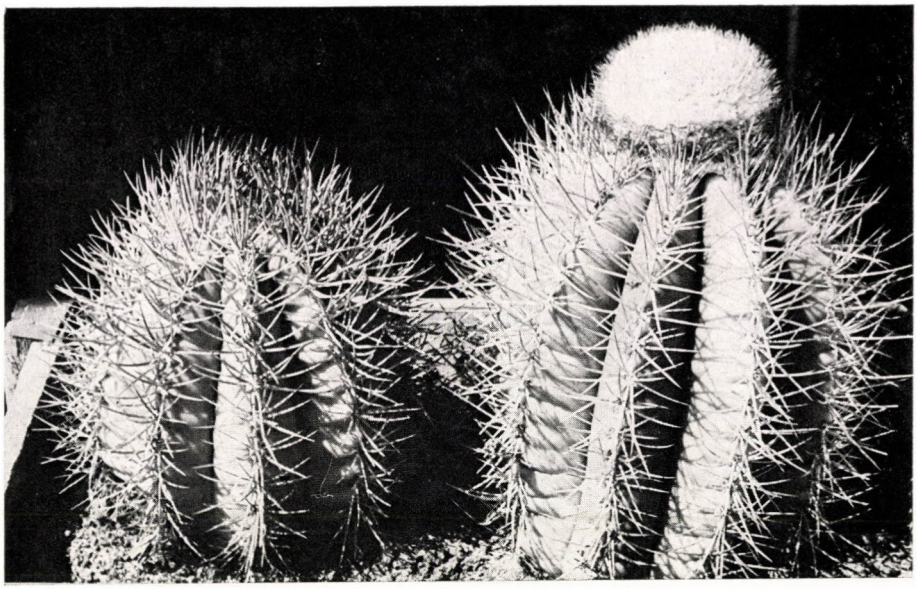


Fig. 8. Melocactus harlowii Britton et Rose

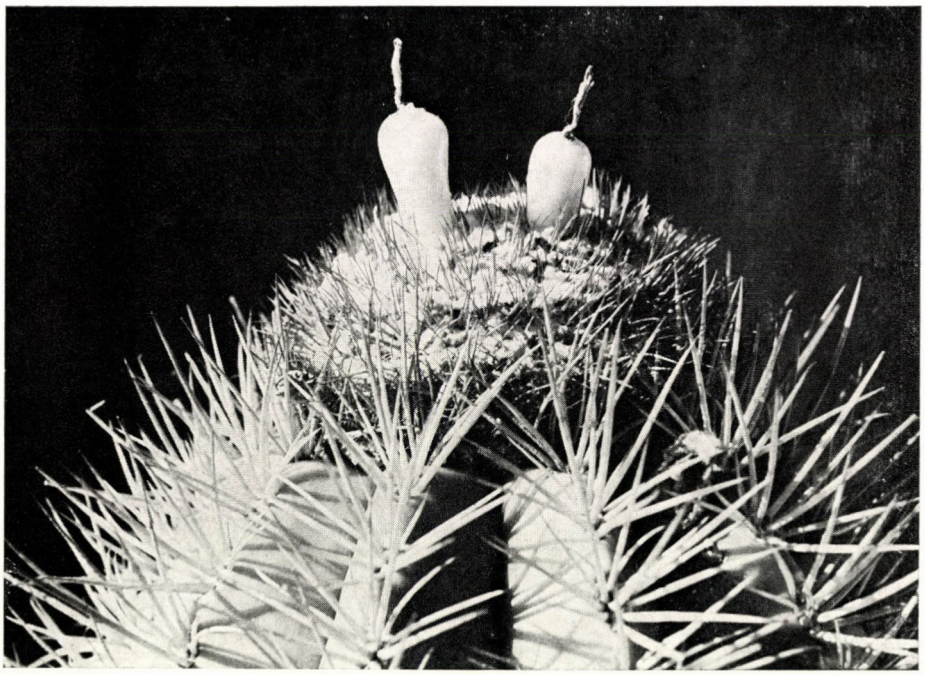


Fig. 9. Melocactus harlowii Britton et Rose f. *candida*

Fig. 10. Melocactus borhidii Mészáros sp. nova

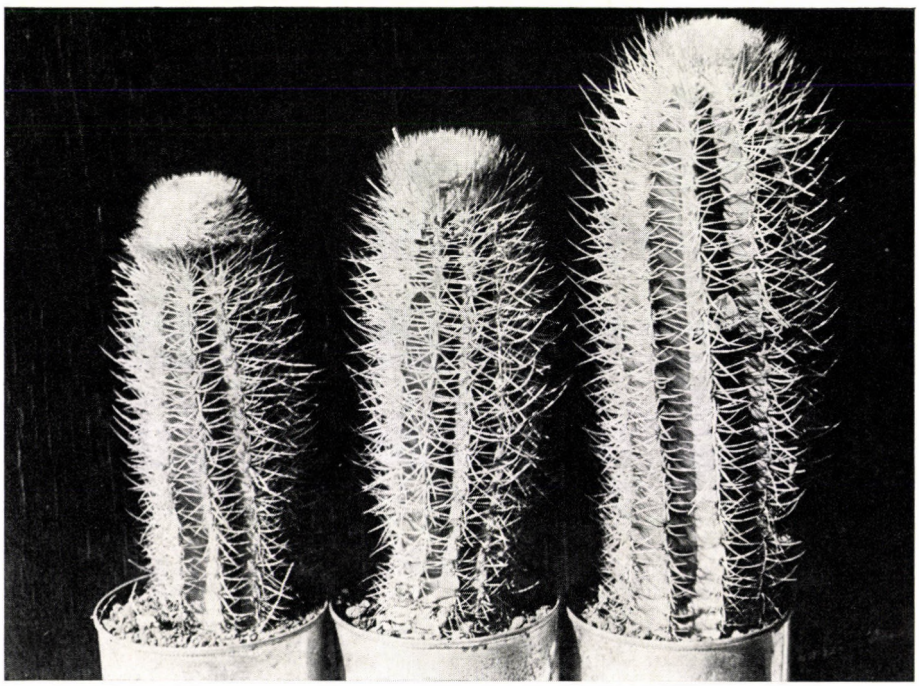


Fig. 11. Melocactus borhidii Mészáros sp. nova

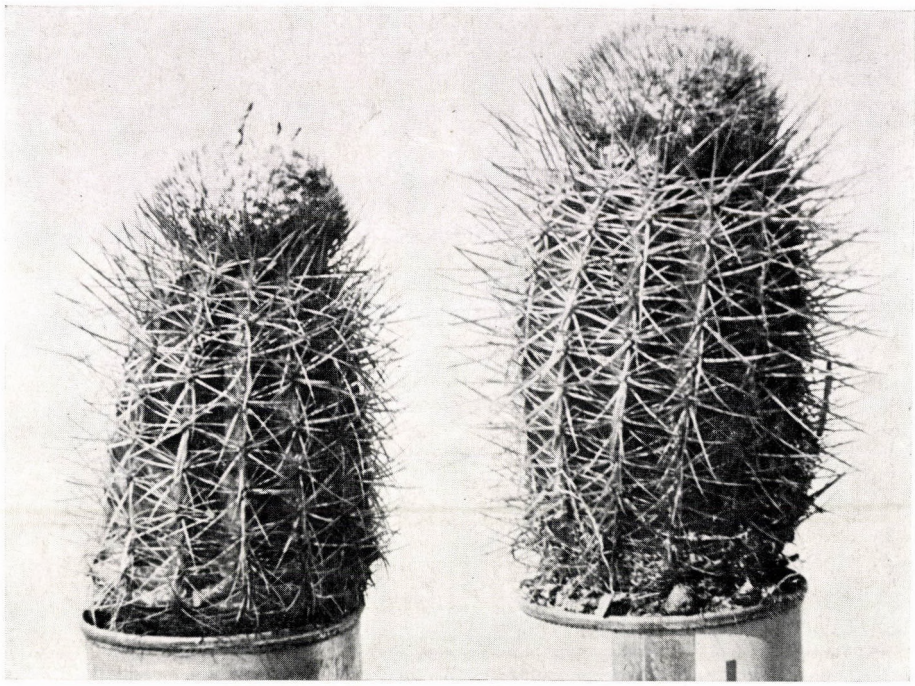


Fig. 12. Melocactus evae Mészáros sp. nova

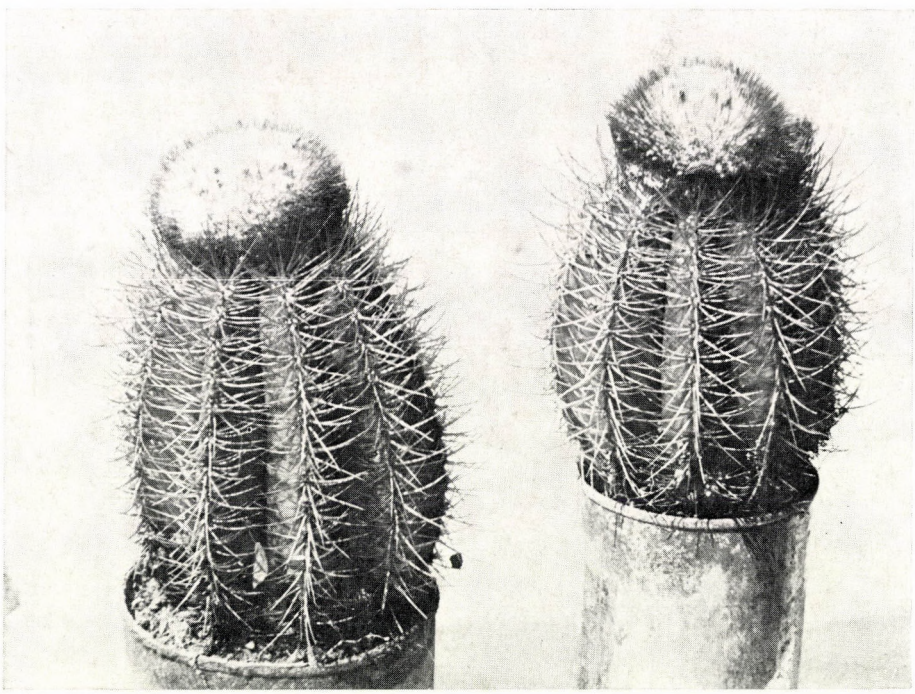


Fig. 13. Melocactus radoczii Mészáros sp. nova

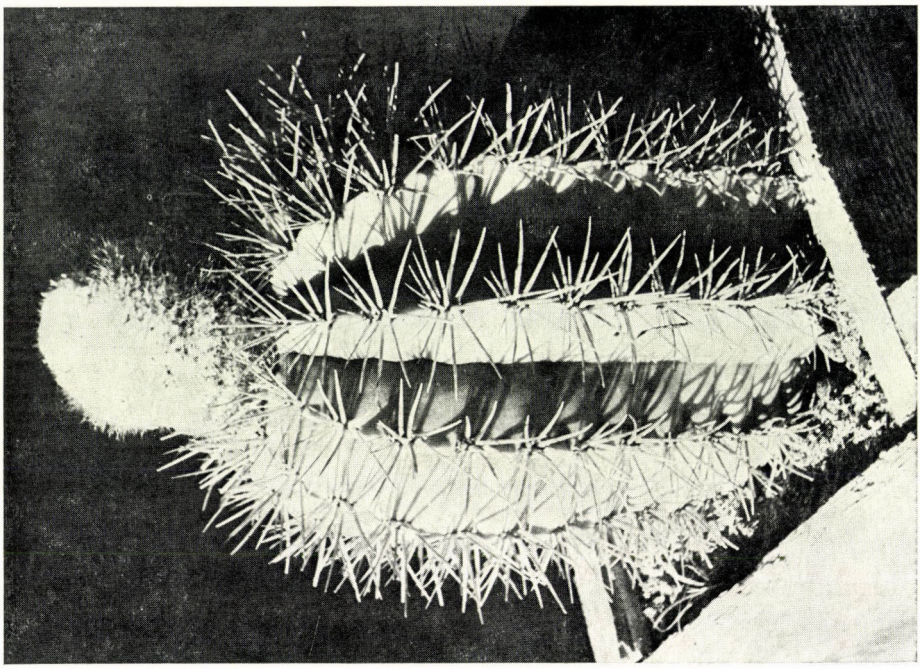


Fig. 15. Melocactus nagyii Mészáros sp. nova

Fig. 14. Melocactus acunai León ssp. *lagunaensis* Mészáros ssp. nova

ACKNOWLEDGEMENTS

It is a pleasant duty to express my gratitude to Elemér NAGY, head of the HAC geologist expedition working in Cuba, as well as to the two members of the expedition, Péter JAKUS and Gyula RADÓCZ, who not only made it possible for me to visit these areas, but who also called my attention to the occurrences of unknown Melocacti and who systematically collected Melocacti at my request, in certain parts of Oriente. It is an equally pleasant obligation to express my thanks to Carlos Estevez MONTES DE OCA for his kind help in the detection of the habitat of *Melocactus matanzanus*. Finally, I am also indebted to Attila BORHIDI, who from the beginning has to a great extent supported my work by his valuable advice.

REFERENCES

BORHIDI, A. (1974): Kubában térképeztünk (We prepared maps in Cuba). Budapest, Gondolat, pp. 241.

BRITTON, N. L. et ROSE, J. N. (1912): Undescribed species of Cuban cacti. Torreya, **12,** 13—16.

LEÓN, H. (1934): El género Melocactus en Cuba. Memorias de la Soc. Cubana de Hist. Nat. **8,** 1—9.

RIHA, J. (1971): The cacti of Cuba. The Nat. Cac. and Succ. Journ. **20,** 36—38.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1—2), pp. 149—161 (9176)

SOME RESULTS OF THE RESEARCHES OF CLUJ CONCERNING THE NUTRITION OF ALGAE

By

I. PÉTERFI, F. NAGY-TÓTH, and A. BARNA

INSTITUTE OF PLANT PHYSIOLOGY, BABEŞ-BOLYAI UNIVERSITY, CLUJ-NAPOCA, ROMANIA

(Received September 10, 1975)

A chronological review of the more important researches concerning the nutrition of algae, made at the University of Cluj, shows that they became more and more advanced.

These studies contributed to the explanation of the role of simple (Cu, Zn, Fe, Ba, Sr, NH_4, K, Mg, Ca, Na, Li; SO_3, SO_4, CO_3, I, CrO_4, HPO_4, NO_2, NO_3, Cl, Br) and complex (nitrato-borates, phosphato-borates, nitrato-phosphates, nitrato-cobalts) anorganic nutrients and of the organic ones (glucides, amino-acids, alcohols, synthetic and endogenous IAA extracted from various plants, gibberelline, ascorbic acid, degranol, merapid) upon the growth and development in pure static and intensive cultures of different alga species and strains *(Chlorella pyrenoidosa, Coccomyxa dispar, Schizochlamys gelatinosa, Scenedesmus acutus, Sc. acutiformis, Sc. obtusiusculus, Sc. quadricauda, Sc. quadrispina, Oocystis pusilla, Stichococcus exiguus, St. mirabilis, St. bacillaris, Gloeotila protogenita, Pseudopleurococcus printzii, Microthamnion kützingianum, Stigeoclonium variabile, Tribonema ulotrichoides)* from Transylvania.

The action of the substances studied with algae and the nutritive medium was in connection with simple media (BENECKE, two types, KNOP—PRINGSHEIM, WITSCH) or more complete ones (KNOP—PRINGSHEIM—FELFÖLDY, TAMIYA "urea EH" and "nitrate A", TAMIYA modified by us), and has allowed the selection of some sensitive strain-biotests — suitable for the demonstration of different substances and for massive cultures — as well as to prove the possibility of using some residual waters for the cultivation of algae.

In the pure cultures of algae, the work done by Professor I. GRINTZESCO (1902, 1903, 1930) made an important contribution. His first monographic papers on the algae *Scenedesmus acutus* (1902) and *Chlorella vulgaris*, studied in pure cultures, became classics in algology. The experimental algology in Cluj has arisen from the activity of this scientist.

Based on pure cultures, I. GRINTZESCO and his co-worker PÉTERFI have minutely studied the genus *Stichococcus* (1932), isolating and comparing the action of different nutritive media and finally identifying and describing several species from Transylvania.

The study in pure cultures of some species of *Stichococcus (St. exiguus, St. mirabilis)* and *Gloeotila (G. protogenita)*, in synthetical solutions of different pH, proved that the tolerance limits of these algae are very large (pH 3.6—9.6). They are euryionic, but their maximum growth is found between pH 6—7. In the acid media, *Stichococcus* shows a more evident growth than *Gloeotila*. In media with pH 6.0—8.0 the developed cells are shorter (Fig. 1) (PÉTERFI, 1939).

The variation of these green filamentous algae in relation with nutritive media was also studied (PÉTERFI, 1947). The action of anorganic ions is different concerning the thallus growth, colony structure, cell growth and division. According to their action on cell division, the anorganic ions may be divided into two large groups:

a) ions stimulating cell division: Cl, SO_4, NO_3, K, Na;

b) inhibiting ions which stop cell division: SO_3, Fe, Li, Sr.

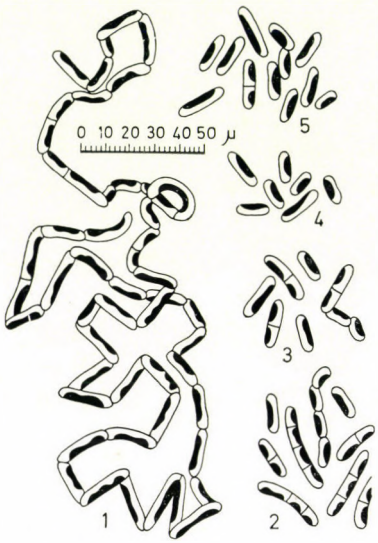


Fig. 1. Thalii of *Stichococcus mirabilis* grown on media with pH 3.65 (1 — fo. *filata*,) 6.00 (2), 6.91 (3), 7.78 (4 — fo. *coccoidea*) and 9.60 (5)

The pH of the nutritive media and the ions, respectively, influence the thallus morphology and structure by regulating the inhibition degree of cell wall biocolloids and the cohesion of the daughter cells. In this way, unicellular thalli (fo. *coccoidea*) arise under the influence of Na and K ions in acid media, and pluricellular filamentous thalli (fo. *filata*) under the influence of Ca ions in neutral and in the weakest alkaline media (Fig. 1). The recent works published by SOEDER and THIELE (1967) and by IWASA and MURAKAMI (1968;1969) about the autosporulation of *Chlorella* and *Chlamydomonas* agree with these conclusions formulated 35 years ago.

A monographic study was devoted to the species *Microthamnion kützingianum*, cultivated on different nutritive media under various light conditions (PÉTERFI, 1933; 1937; GRINTZESCO — PÉTERFI, 1936). In these researches the sexual reproduction of alga was discovered and its reproductive cycle was established (1933). The action of nutritive medium composition and concentration was also noted (1937), as well as the effect of different microelements (1936) on its

growth and development. This alga shows different shapes according to medium firmness (liquid or solid), reaction (acid, neutral or alkaline pH) and composition (sources and concentrations of nutrients). On firm media the thalli are grouped in colonies, the vegetative growth is obvious and the cells tend to have an isodiametrical shape. Development limits vary between pH 3.2—8.8, but the optimum growth is found at pH 5.0—6.0 (Fig. 2).

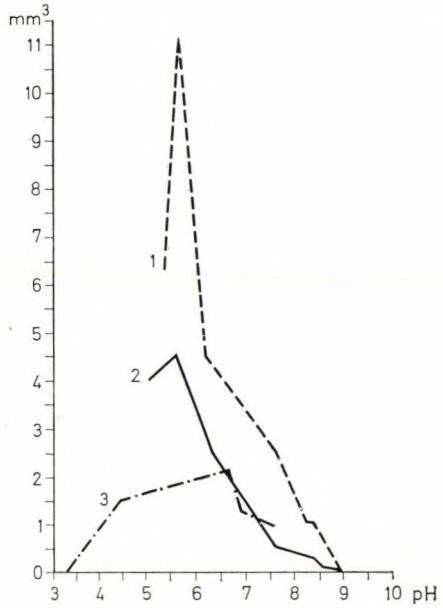


Fig. 2. Growth of *Microthamnion kützingianum* depending of the complete BENECKE medium pH (1), free of Ca (2), or supplemented with H_2SO_4, or NaOH, respectively (3)

Microthamnion kützingianum can use mineral and organic nitrogen (Fig. 3) as well as several organic substances (glucides, organic acids, glycerine) which activate its growth.

The cations and anions were added to some nutritive media in equimolecular quantities (M/40—M/25) which, following the numerous experiments, proved to be optimum for this species. It was established that the cations and anions — depending on their effects upon the alga — can be placed in the following toxicity liotrop series:

Cations:	Cu	Zn	Fe	Ba	Sr	NH_4;	K	Mg	Ca	Na
Anions:	SO_3	CO_3	I;	CrO_4	HPO_4	NO_2	Cl	Br	NO_3	SO_4

Sodium chloride added to nutritive solutions enhanced the growth of *Microthamnion kützingianum*. The range of optimum growth is between 0.97—2.92 g/l.

The nutrition problems were more deeply studied in the researches concerning the action of some microelements (GRINTZESCO—PÉTERFI 1936, PÉTERFI, 1937). By means of pure *Microthamnion* cultures, the effect of Mn, Zn, and F (1936), and of Li, Cu, B, Al and Co (1937), respectively, was biotested. It was

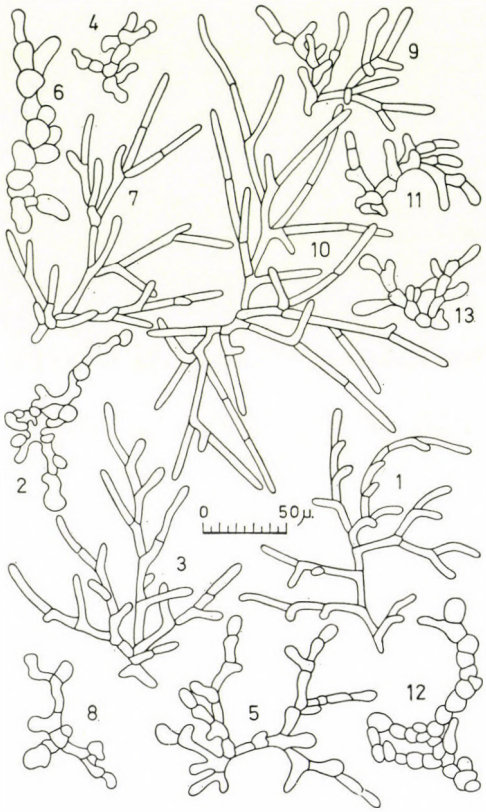


Fig. 3. Effect of different N sources upon the growth of *Microthamnion kützingianum;* BENECKE medium with KNO_3 (1), KNO_2 (2), NH_4NO_3 (3), $(NH_4)_2HPO_4$ (4), $(NH_4)_2SO_4$ (5), NH_4-oxalate M/40 (6), and M/160 (7), NH_4-tartarate (8), asparagine M/40 (9), M/80 (10) and M/160 (11), and peptone (12)

found that very high dilutions of these elements favour the growth and reproduction of the species. The optimum concentration for $MnCl_2$ was of 0.0001 gl for $ZnCl_2$ it varied between 0.0001—0.00001 g/l, and for NaF between 0.01—0.001 g/l. The yield increase under the influence of $MnCl_2$ was of 150%, of $ZnCl_2$ 50% and of NaF 100%. Thus in experimental conditions, Zn was more toxic than F.

These results, published 30 years ago, represent a significant experimental performance even in the light of the recent advances regarding the action of microelements (cf. DEAR—ARONOFF, 1968).

The action of certain complex anorganic salts was thoroughly studied by our group. Experiments were made on effect of borato-phosphate (PÉTERFI et al., 1958), nitrato-phosphate (PÉTERFI et al., 1962), and nitrato-cobalt (PÉTERFI et al., 1961; 1964; 1973), on static and intensive cultures of *Coccomyxa dispar*, *Scenedesmus quadrispina*, *Sc. acutiformis* and *Stigeoclonium variabile*. The results showed that the growth of these algae was stronger in the presence of complex salts than in their chemical simple equivalents. For *Coccomyxa* and *Stigeoclonium*, the optimum concentration of borato-phosphate and nitrato-phosphate varied around 0.05%. The growth and development difference depend also on the relation of the complex elements. Thus, in the case of borato-phosphate complex, at the relation 1 B : 1 P, the increase was 198% in comparison with the control in BENECKE solution; in the relation 1 B : 4 P it was 388%. In the case of the nitrato-phosphate complex, at the proportion 1 N : 1 P, the increase was 390%, and at the proportion 1 N : 5 P it was 428%.

The chlorine-pentamine-cobalt-chloride ($Co(NH_3)_5Cl)Cl_2$) and the nitrate-hexamine-cobalt ($Co(NH_3)_6)(NO_3)_3$) complex also stimulated the growth of the algae studied; this latter salt proved to be better and *Scenedesmus quadrispina* reacted to it more sensitively (Fig. 4).

Nitrate-hexamine-cobalt was also used under intensive cultivation conditions with *Scenedesmus acutiformis*. It was showed (PÉTERFI et al. 1973) that the optimum concentration is 0.001 mg%, but that the favourable action is more moderate under intensive conditions than in static runs (Fig. 5). This may be due not only to the much more favourable nutritive conditions but probably to the season periodicity of algae. It was found that in *Stigeoclonium* the action of complex salts is faster in summer and slower in autumn; in *Scenedesmus acutiformis*, on the other hand, the optimum growth was recorded during the spring and late autumn months (PÉTERFI—NAGY-TÓTH, 1972).

The fact that the complex salts have a markedly higher favourable action than the similar simple salts proves that they are absorbed, probably as molecules or as complex ions, and thus they enhance the metabolism and therefore the multiplication of algae.

These results may be important for the use of some preparations where the nutritive substances should be combined in different optimum proportions, balanced for massive cultures; they are also important in view of the use of some contaminating residues.

The high tolerance of algae towards the quality and quantity of the substances, as well as their capacity of concentrating ions from more diluted media — found also in the experiments mentioned — demonstrate that these organisms are suitable for water decontamination with radionuclides. In this line of study, the accumulation of ^{90}Sr and ^{134}Cs by *Scenedesmus acutus* was successfully experimented (PÉTERFI et al., 1966) (Fig. 6).

The researches on the action of some organic substances, physiologically ative upon the algae, are of interest for biotesting and for productivity stimulation. It was showed that IAA stimulates the multiplication through zoo-

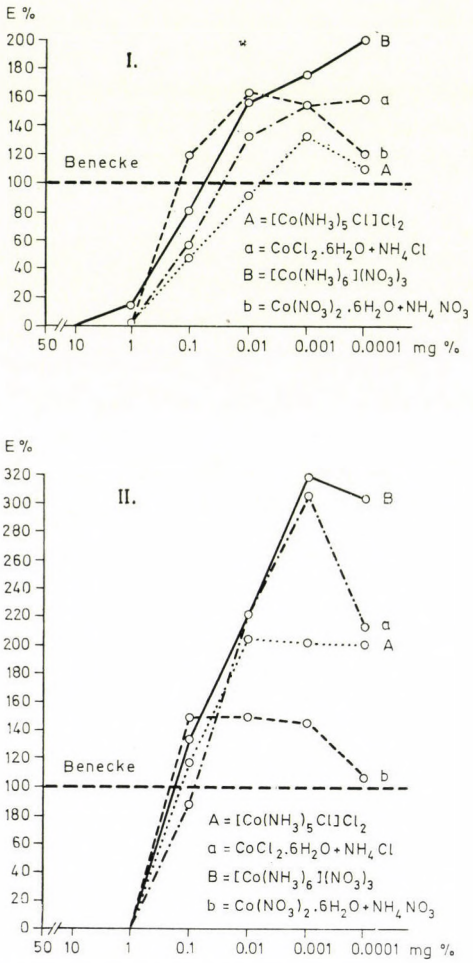


Fig. 4. Effect of complex (A, B) and simple (a, b) salts upon the growth of *Coccomyxa dispar* (I) and *Scenedesmus quadrispina* (II) in static cultures

gonidia and gametes, as well as cell division and growth of the pure cultures od *Microthamnion kützingianum* and *Pseudopleurococcus printzii*; its action is more favourable in an alkaline than in an acidic medium (PÉTERFI, 1946). In the case of static pure cultures of *Scenedesmus quadrispina*, the effect of synthetic IAA was much more reduced (142%) than that of the endogenous substances extracted from corn (Csanád 117 and Fleischmann 481), vernalized and non-vernalized (180—351%). The gibberellic acid, added to the BENECKE

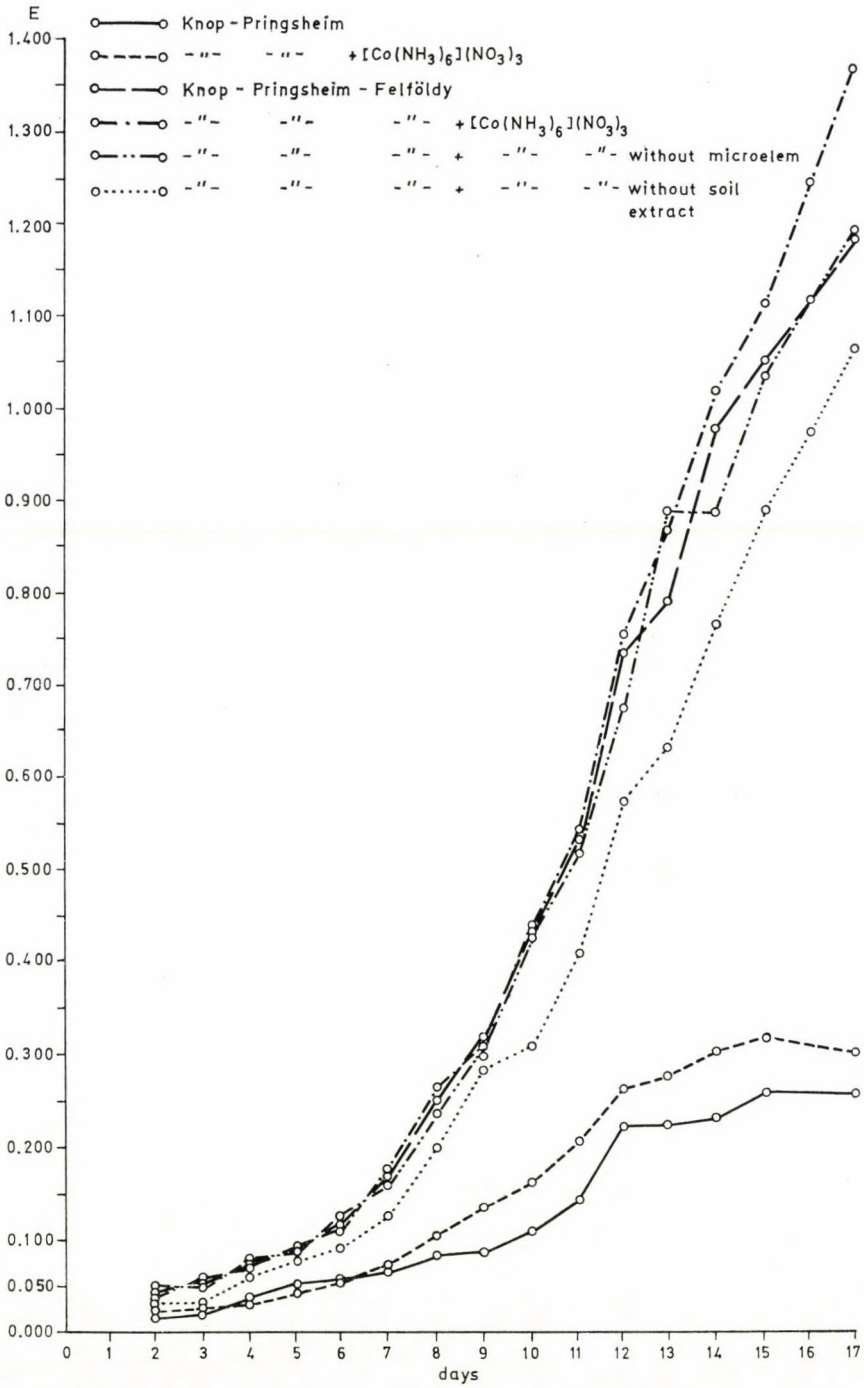


Fig. 5. Effect of nitrate-hexamine-cobalt complex in simple (KNOP—PRINGSHEIM) and complete (KNOP—PRINGSHEIM—FELFÖLDY) nutritive solutions on the intensive cultures of *Scenedesmus acutiformis*

nutritive medium in concentrations of 1.0—10.0 mg%, stimulated the multiplication of *Scenedesmus quadrispina*, *Coccomyxa dispar* and *Stigeoclonium variabile*. The most sensitive was *Sc. quadrispina* (PÉTERFI—NAGY-TÓTH, 1963). In *Oocystis pusilla*, *Scenedesmus quadricauda* and *Microthamnion kützingianum*, the ascorbic acid, in suitable concentrations (10—50 mg%), also stimulated cell division, but did not influence the lengthwise growth of cells. The increase of cellular biomass was 3—15 times higher than that of the controls (PÉTERFI,

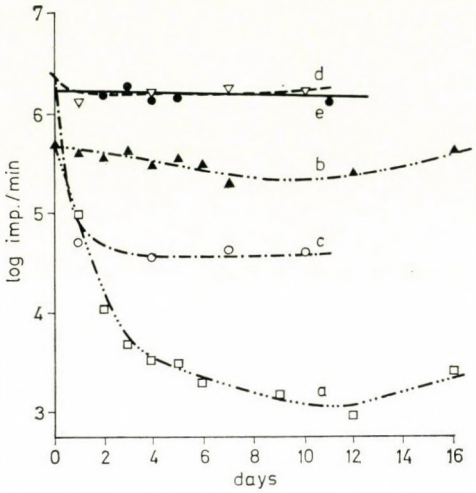


Fig. 6. Accumulation of ^{90}Sr by *Scenedesmus acutus* from solutions of 0.0345 μCi (a) and of 0.06909 μCi (c), and its concentration variation in solutions non-inoculated with algae (b, d). ^{134}Cs was not accumulated (e)

1948). Among the cytostatic substances, degranol and merapid were biotested. In a concentration of 1.0 mg%, degranol hinders the growth and multiplication of *Stigeoclonium variabile*, but *Coccomyxa dispar* grows also at 100 mg% (PÉTERFI et al., 1959). Merapid, added to BENECKE solution in concentrations of 1000—10 mg%, inhibits the multiplication of these two species, but in smaller concentrations it stimulates this process (PÉTERFI—BRUGOVITZKY, 1965).

These experimental investigations, confronted with reference bibliographical data, have suggested some theoretical generalizations about the role of algae in the treatment of polluted water (PÉTERFI et al., 1972), their use as biotests (PÉTERFI—NAGY-TÓTH, 1973), and the principles of nutritive media preparation (PÉTERFI—NAGY-TÓTH, 1973).

On the basis of the experience accumulated in our laboratory, the studies were directed toward the possibilities of intensive cultivation of algae. There were devised and made some equipments of the closed-circuit type, appropriate for intensive cultures under long standing sterile conditions (PÉTERFI—NAGY-

Tóth, 1967). Some elements of the methodology used in our equipment were applied by also other research workers (the spraying system of the bubbling gas by Clement, 1968; the method of air sterilization by Eichhorn, 1969).

The comparative experiments with the native species *Chlorella pyrenoidosa*, *Scenedesmus acutiformis*, *Schizochlamys gelatinosa* and *Tribonema ulotrichoides* in these devices, in simpler media suitable for static cultures (e.g. Benecke) and in complete media (Benecke and Knop—Pringsheim supplemented with microelements and soil extract) intended for intensive cultures, have shown that for strains selection the solutions poorer in nutrients — where the sensitivity of organisms is more evident — are recommended, while for biomass yield the complete and balanced ones (Péterfi–Nagy-Tóth, 1967/a). The experiments with *Scenedesmus acutiformis* proved that the increased biomass yield by the simple increase of the nutrient of a given medium is limited (Péterfi, Nagy-Tóth 1967/b), and that the reactions of *Scenedesmus* (*Sc. acutiformis*, *Sc. acutus*, *Sc. obtusiusculus*) to the complete nutritive solutions are different (Péterfi et al., 1967) (Table 1). Therefore, for almost every species or alga strains several alternative combinations must be tried, until a satisfactory solution variant is obtained. The more complete factor of the nutritive media is the soil extract. Added to the Tamiya "urea EH" in a proportion of 1 : 9, it produces the intensification of cell multiplication and consequently an increased biomass, both in *Scenedesmus acutiformis* (Péterfi et al., 1969) and in *Stichococcus bacillaris* (Marton, 1975). In Knop—Pringsheim and Tamiya, supplemented with soil extract and applying the fractionated sampling, a long lasting (continuous) cultivation of *Scenedesmus acutiformis*, *Sc. acutus* and *Sc. obtusiusculus* was possible (Péterfi et al., 1969) (Fig. 7), without a decrease of the yield. The "autoinhibitors" biotesting with the alga itself was negative.

Among the studies intended to find the more appropriate conditions of nutrition, there were a series of researches on the possibilities of using mineral and residual waters for the intensive cultivation of algae. It was found that Tamiya nutritive solution supplemented with soil extract and diluted with an equal volume of "Zizin" mineral water is an excellent new nutritive solution for *Scenedesmus acutiformis* (Péterfi – Nagy-Tóth, 1970). The use of the residual water from the beer factory in Cluj, in different combinations with nutritive solutions and natural or mineral waters, had the result of stimulating the growth of *Scenedesmus acutiformis* (Péterfi et al., 1974) (Fig. 8) and meanwhile purifying the residual water (Barna, 1973; 1974).

These briefly presented results, representing the work performed over three decades lead to the conclusion that only complex studies can contribute to the explanation of the complicated physiological processes of algae. Only this kind of investigation will demonstrate that algae could be used without risks for the solving of some contemporary problems.

Table 1

Influence of medium and light conditions upon the growth and composition of Scenedesmus

No	Algae[1]	Nutritive solution[2]	Light, lux[3]	Cultivation, days	Extinction	Cells/mm³	Dry weight, g/l	Total sugar, %/d. w.	Proteins, %/d. w.	Total sugar/ Froteins
1.	a	Knop-Pringsheim-Felföldy	6500	41	0.600	75,125	1.52	14.20	45.00	0.31
	b				0.503	101,375	1.17	13.65	50.18	0.26
	c				0.585	111,125	1.86	29.10	36.00	0.80
2.	a	Knop-Pringsheim-Felföldy	5000	11	1.350	146,625	4.59	33.90	22.25	1.52
		Idem+EDTA and urea instead of KNO_3		15	1.580	186,250	5.02	12.40	53.12	0.23
		Tamiya (original form)		15	0.835	87,750	2.30	5.20	57.19	0.09
		Tamiya-modified +soil extract)		11	1.590	226,000	5.82	3.85	56.43	0.068
3.	a	Knop-Pringsheim-Felföldy+ +ethanol in 25%	5000	10	1.295	114,375	3.90	26.80	20.94	1.28
		Knop-Pringsheim-Felföldy			1.310	153,125	3.76	35.50	23.62	1.50
4.	a	Tamiya-modified+"Zizin" mineral water	5000	8	1.510	323,875	4.33	5.10	63.75	0.08
		Tamiya-modified			1.230	190,875	3.14	5.45	57.50	0.094
5.	a	Knop-Pringsheim-Felföldy	B→R→Y→W[4], W←Y←R←B 4000	11	1.110	117,250	3.24	25.37	34.38	0.73
					1.280	122,500	4.61	34.90	24.19	1.40
6.	a	Tamiya-modified	5000—6400— —8000—13,000 5000	9	1.860	250,000	7.12	6.20	55.25	0.11
					1.680	270,375	5.62	6.00	50.00	0.12
7.	a	Tamiya-modified, daily refreshed in proportion of 0.10	6000	30	1.470	278,125	3.83	6.30	63.12	0.099
		Idem in proportion of 0.15			1.260	256,375	3.28	5.95	62.69	0.094
		Idem in proportion of 0.20			1.240	215,312	3.08	4.80	61.19	0.078

1. Algae: a — *Scenedesmus acutiformis* Schroed., b — *Sc. obtusiusculus* Chod., c — *Sc. acutus* (Meyen) Chod.
2. In No. 1 the cultivation was carried out in vertical columns with central illumination, for No. 2—7 parallel-piped vessels were used
3. Length of light period: 12 hours, alternated with 12 hours of dark
4. After 12 hours of dark, 1 hour of B — blue light of 400—600 nm and 1400 lx intensity; R — red light of 530—750 nm and 1700 lx; — yellow light of 440—650 nm and 3100 lx. Before the end of the light period the succession was inverse

Fig. 7. Variation of optical density (a) and of dry substance (b) in the intensive cultures of *Scenedesmus acutiformis*, daily refreshed in proportion of 0.10 (1), 0.15 (2) and 0.20 (3)

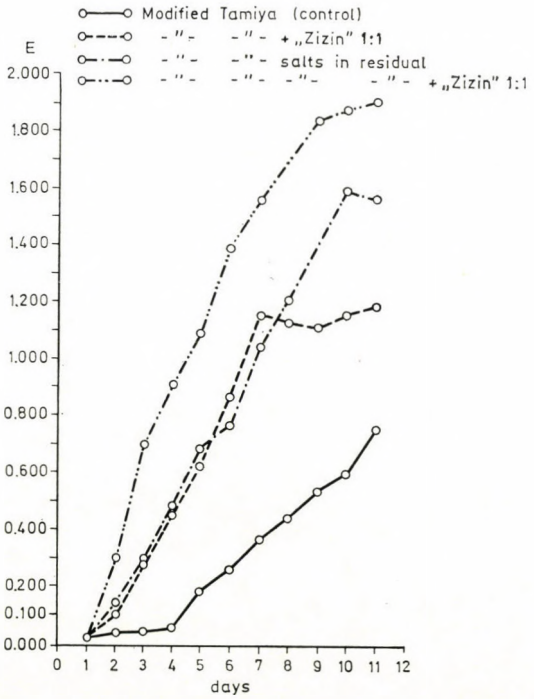


Fig. 8. Growth of *Scenedesmus acutiformis* intensive cultures in media prepared with residual water from the beer factory

REFERENCES

BARNA, A. (1973): Forschungen bezüglich der intensiven Züchtung der Alge Scenedesmus acutiformis in Nährlösungen erzeugt mit Abwasser der Bierfabrik Cluj. Studia Univ. Babeş-Bolyai, ser. Biol. **2,** 51—59.

BARNA, A. (1974): Recherches sur la culture intensive de l'algue Scenedesmus acutiformis dans des solutions nutritives préparées avec l'eau résiduaire de la brasserie de Cluj (II). Studia Univ. Babeş-Bolyai, ser. Biol. **1,** 67—71.

CLEMENT, G. (1968): Étude d'une culture d'algues en vue d'une production de grande échelle. Materialü 6-go Koordinatsionnogo Simpoziuma po Teme VI. **5. 5** SEV, Sofia (s. p.).

DEAR, J. M.—ARONOFF, S. (1968): The non-essentiality of boron for Scenedesmus. Plant Physiol. **43,** 997—998.

EICHHORN, M. (1969): Zur Stoffproduktion kontinuierlicher Kulturen von Scenedesmus obliquus (Turp.) Kützing im Dauerlicht bei Phosphat- und Nitrat-Limitation. Flora (Jena), Abt. A, **159,** 494—506.

GRINTZESCO, J. (1902): Recherches expérimentales sur la morphologie et la physiologie de Scenedesmus acutus Meyen. Bull. Herb. Boiss., 2e sér., **3,** 217—288.

GRINTZESCO, J. (1903): Contribution à l'étude des Protococcacées Chlorella vulgaris Bey. Rev. Général Bot. **15,** 1—31.

GRINTESCU, I. (1930): Les cultures pures et leur importance pour l'étude des algues, des schizophytes et des champignons. Intîiul Congres Naţional al Naturaliştilor din România ţinut la Cluj de la 18 pîna la 21 aprilie 1928. Ed. Soc. Stiinţe, Cluj, 171—173.

GRINTZESCO, J.—PÉTERFI, ST. (1932): Contribution à l'étude des algues vertes de Roumanie. Rev. Algol. (Paris), **6,** 159—175.

GRINŢZESCO, J.—PÉTERFI, St. (1936): Sur l'action du manganése, du zinc et du fluor sur le développement du Microthamnion Kützingianum Naeg. Bul. Soc. Chim. România **18,** 177—181.

IWASA, K.—MURAKAMI, S. (1968): Palmelloid formation of Chlamydomonas. I. Palmelloid induction by organic acids. Physiol. Plant. **21,** 1224—1233.

IWASA, K.—MURAKAMI, S. (1969): Palmelloid formation of Chlamydomonas. II. Mechanism of palmelloid formation by organic acids. Physiol. Plant. **22,** 43—50.

MARTON, AL. (1975): Forschungen über die intensive Kultur der Grünalge Stichococcus bacillaris Nägeli in verschiedenen Nährmedien. Rev. Roum. Biol. **20,** 49—53.

PÉTERFI, ST. (1933): Sur la reproduction de Microthamnion Kützingianum Naeg. Bul. Soc. Sci. Cluj **7,** 170—173.

PÉTERFI, ST. (1937): Contribuţiuni la morfologia şi fiziologia algei verzi Microthamnion Kützingianum Naeg. (Thesis), Ed. Minerva, Cluj, 1—165.

PÉTERFI, ST. (1939): Der Einfluss der Wasserstoffionenkonzentration (pH) auf die Entwicklung der einzelligen und mehrzelligen Stadiums bei Stichococcus und Gloeotila. Bul. Grad. Bot. şi al Muz. Bot. Univ. Cluj **19,** 143—152.

PÉTERFI, I. (1946): The influence of the beta-indole-acetic acid on the growth and multiplication of the algae. Acta Bolyaiana (Cluj-Kolozsvár) **1,** 44—69.

PÉTERFI, I. (1947): The influence of some inorganic ions upon the growth of the filamentous thalli of some Ulothrichaceae. Acta Bolyaiana (Cluj-Kolozsvár) **1,** 147—155.

PÉTERFI, I. (1948): The effect of the ascorbic acid upon the multiplication of some green algae. Acta Bolyaiana (Cluj-Kolozsvár) **2,** 75—80.

PÉTERFI, ST.—BARNA, A.—NAGY-TÓTH, FR. (1972): The algae as means for treating the polluted waters. Natura (Bucureşti), **3,** 6—13.

PÉTERFI, ST.—BARNA, A.—NAGY-TÓTH, FR. (1974): La culture de l'algue Scenedesmus acutiformis dans de milieux composés d'eaux résiduaires et minérales. Studia Univ. Babeş-Bolyai, ser. Biol. **1,** 25—33.

PÉTERFI, I.—BRUGOVITZKY, E. (1965): Wirkung des Merapids auf das Wachstum der Pflanze. Physiol. Plant. **18,** 359—367.

PÉTERFI, I.—BRUGOVITZKY, E.—KOZMA, J.—NAGY-TÓTH, F. (1959): The effect of Degranol on the growth of plants. Acta Biol. Acad. Sci. Hung. **10,** 187—196.

PÉTERFI, ST.—BRUGOVITZKY, E.—NAGY-TÓTH, FR. (1958): Contributions à la connaissance de l'influence de quelques sels complexes sur le développement des algues vertes. (I). Studii şi Cercet. Biol. (Cluj) **9,** 249—260.

PÉTERFI, ST.—BRUGOVITZKY, E.—NAGY-TÓTH, FR. (1962): Recherches sur l'influence de certains sels complexes sur le développement des algues vertes. (II). Studia Univ. Babeş-Bolyai, ser. Biol. **1,** 67—74.

PÉTERFI, ST.—BRUGOVITZKY, E.—NAGY-TÓTH, FR. (1964): Contributions à la connaissance

de l'influence de certains sels complexes sur le développement des algues vertes. (III). Studia Univ. Babeş-Bolyai, ser. Biol., **1,** 59—63.

PÉTERFI, ST.—BRUGOVITZKY, E.—NAGY-TÓTH, FR. (1963): Die Wirkung der Vernalisation auf den Wuchs- und Hemmstoffgehalt des Winterweizens. Naturwissenschaften **50,** 621—622.

PÉTERFI, ST.—NAGY-TÓTH, FR. (1963): L'action de la gibbérelline sur la croissance des algues vertes. Comunicările Acad. R. P. R. **13,** 957—962.

PÉTERFI, ST.—NAGY-TÓTH, FR. (1967a): Untersuchungen über Massenkulturen von Süsswassergrünalgen. Rev. Roum. Biol.-Bot. **12,** 199—206.

PÉTERFI, ST.—NAGY-TÓTH, FR. (1967b): Untersuchungen über die Massenkultur der Grünen Alge Scenedesmus acutiformis Schroed. Rev. Roum. Biol.-Bot. **12,** 289—294.

PÉTERFI, ST.—NAGY-TÓTH, FR. (1970): Die Rolle einiger natürlicher Wasser in der Ernährung der Algen. Contrib. Bot.-Cluj, 357—364.

PÉTERFI, ST.—NAGY-TÓTH, FR. (1972): Das Wachstum der Alge Scenedesmus acutiformis in intensiven Kulturen zu verschiedenen Jahreszeiten. Studia Univ. Babeş-Bolyai, ser. Biol. **2,** 39—45.

PÉTERFI, ST.—NAGY-TÓTH, FR. (1973): Algae as biotests. Progresele Ştiinţei **9,** 437—447.

PÉTERFI, ST.—NAGY-TÓTH, FR. (1973): Die Prinzipien zur Herstellung der Algennährmedien. Contrib. Bot.-Cluj, 219—225.

PÉTERFI, ST.—NAGY-TÓTH, FR.—BARNA, A. (1967): The productivity of some Romanian Scenedesmus species in pure cultures. Rev. Roum. Biol.-Bot. **12,** 373—377.

PÉTERFI, ST.—NAGY-TÓTH, FR.—BARNA, A. (1969): Wachstumsverlauf von Scenedesmus acutiformis in periodisch verdünnten intensiven Kulturen. Studia Univ. Babeş-Bolyai, ser. Biol., **1,** 73—82.

PÉTERFI, ST.—NAGY-TÓTH, FR.—BRUGOVITZKY, E. (1969): Die Variation der Kohlenhydrate und der Protide bei Scenedesmus unter verschiedenen Anzuchtbedingungen. Contrib. Bot.-Cluj, 321—329.

PÉTERFI, ST.—NAGY-TÓTH, FR.—BRUGOVITZKY, E. (1973): Contribution to the knowledge of the influence of complex salts upon the growth of green algae. (IV). Studia Univ. Babeş-Bolyai, ser. Biol., **2,** 29—41.

PÉTERFI, ST.—PAVEL, T.—NAGY-TÓTH, FR. (1966): Aufspeicherung des Sr^{90} und Cs^{134} durch die Grünalge Scenedesmus acutus Meyen. Rev. Roum. Biol.-Bot. **11,** 327—331.

SOEDER, C. J.—THIELE, D. (1967): Wirkungen des Calcium-Mangels auf Chlorella fusca Shihira et Krauss. Zeitschr. f. Pflanzenphysiol. **57,** 339—351.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1—2), pp. 163—183 (1976)

BIOCLIMATIC STUDIES IN THE ULUGURU MOUNTAINS (TANZANIA, EAST AFRICA)

II. CORRELATIONS BETWEEN OROGRAPHY, CLIMATE AND VEGETATION

By

T. Pócs

HO SI MINH TEACHERS' COLLEGE, DEPARTMENT OF BOTANY, EGER

(Received February 1, 1976)

The first paper of this series discussed the microclimatic conditions in several natural and secondary ecosystems (Pócs, 1974: 115—135).

The present paper is an attempt to find correlations between the orography and the climatic conditions, and between the climatic conditions and the distribution of different vegetation types in the Uluguru Mountains, by the aids of vegetation tarnsects and of Gaussen—Walter diagrams; and finally to establish the altitudinal zonation there.

Introduction

To obtain useful information concerning the climatic conditions which determine the vegetation boundaries in the Uluguru Mountains, I studied the available data of different sources (East African Met. Dept. 1964, 1971 and Jackson, 1970). A sketchy rainfall map of the Ruvu basin was drawn by Jackson, and a more detailed one of the Uluguru Mountains by the author (l. c. and Pócs, 1976/a). Jackson went in details of the probability of rainfall, while the author analysed the duration of the dry season in the mountains, both factor being important for crop production.

Although there are more than 30 rainfall recording stations, mainly at lower elevations of the mountains, only two of them measured systematically also temperature, and one, the Morogoro Agricultural Office, where it is being recorded since long (for more than 50 years).

The rainfall distribution itself seemed to me insufficient to explain the great diversity of vegetation types. The very variable relief combined with the effect of the eastern rain carrying winds produced a very interesting, complicated asymmetric pattern in the distribution of vegetational elements and also in the agricultural potential of the area.

Therefore I attempted to find an indirect method to obtain temperature data for the mountains and to construct this way Gaussen—Walter diagrams for all Uluguru rain gauge stations. These diagrams proved to be very useful in the climatological interpretation of the vegetation.

Methods

For the composition of diagrams, the temperature values were estimated by extrapolation from the data available for Tanzania, from a total of 35 stations. "If the height of a location is known, its temperature may be calculated with a probable error of only 2° Fahrenheit" (East Afr. Met. Dept. 1959). This is by far not so simple. MOREAU (1935), analysing the climate of the Usambara Mountains, has found different gradients in the eastern and in the western

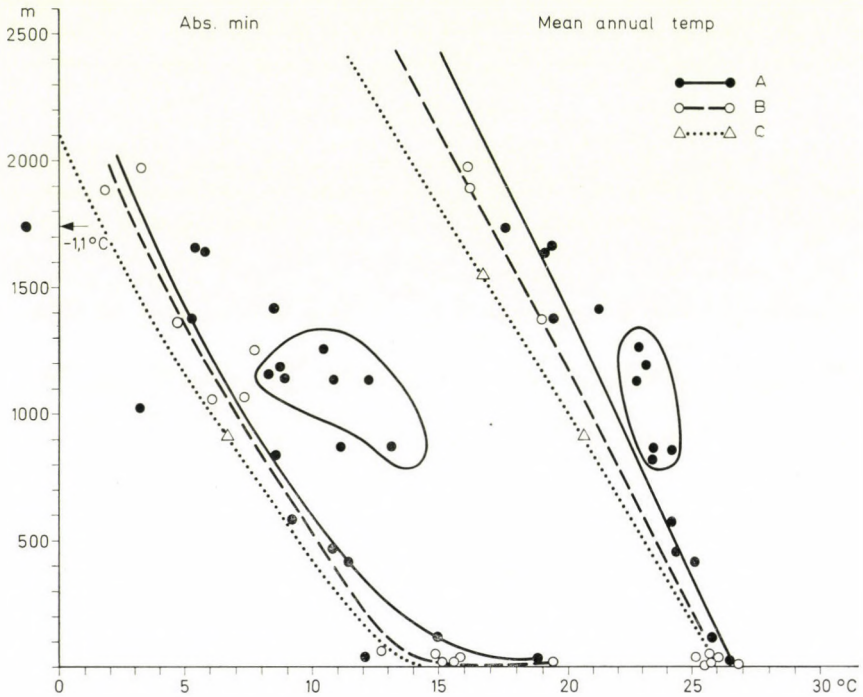


Fig. 1. Variation in absolute minimum temperature with height in Tanzania (left). Variation in mean annual temperature with height (right). A: Stations located in the dry forest and in woodland zones. B: in the mesophilous, and C: in the rain forest zones. (Values of lake and central plateau stations framed)

parts, and established that "the Usambara Mountain temperatures are exceptionally low for their altitude and in particular lower than those for Kenya at corresponding altitudes". KENWORTHY (1966) also pointed out when he analysed the temperature gradients against the altitude in tropical East Africa. He found that the obtained data show often a deviation of 2—3°C from the average, and that the thermal gradient in the drier West Kenya is less than in the more cloudy eastern part of the Kenyan Highland.

When I analysed the temperature data of Tanzania, I found an interesting connection between the values of temperature and the vegetation zone from where the data were obtained. The main temperature at the same altitude above the sea level shows a gradual decrease from the grassland and semidesert thicket, through the woodland, dry forest and closed forest zones, to the rain forest belts. If we represent the thermic gradients for the different vegetation zones by different curves, we can diminish the error of this method from an interval of 2—4 to 0.5—1 centigrades among limited conditions (see the Figs 1, 2, 3). The method could be applied to calculate the main annual temperature, the main temperature of the warmest and that of the coldest month and, with some restrictions, to obtain the absolute minimum temperatures. The method was not accurate enough for stations in the centre of the East African Plateau

and near Lake Victoria. In both cases the values, especially the coldest month's temperature and the absolute minima, are higher than expected owing to the plateau heating effect (see KENWORTHY, l. c.) and to the water mass of the Lake.

One more interesting fact appeared from the data: the warmest time of the year falls at a much earlier date in the interior of the continent, and follows gradually later seawards. In Tanzania the warmest month varies from September to February or March (see Fig. 4).

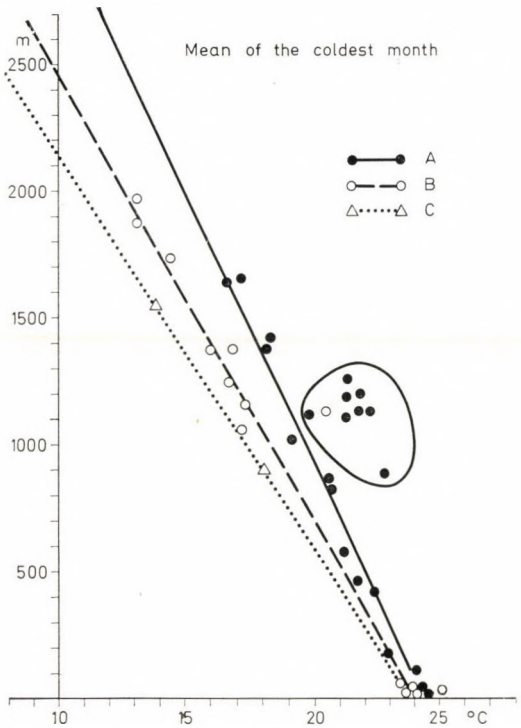


Fig. 2. Variation in mean temperature of coldest month with altitude in Tanzania

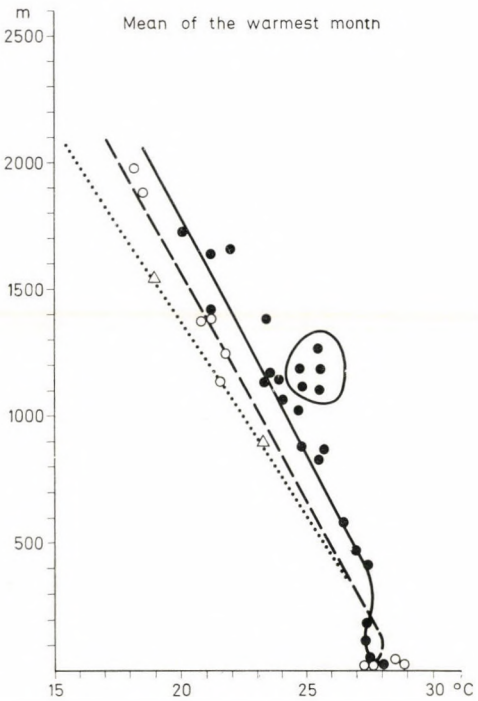


Fig. 3. Variation in mean temperature of warmest month with altitude in Tanzania

Discussion

By the aid of the obtained temperature data for the rain stations, GAUSSEN—WALTER diagrams were drawn in an attempt to find the climatic factors which determine the existence of different vegetation types and which delimit their boundaries. The following transects show parallelly the relief, climatic elements and vegetation types in the northern and in the southern half of the Uluguru Mountains (Fig. 7). The location of the rain measuring stations for which GAUSSEN—WALTER diagrams were drawn, and the lines along which the vegetation transects were figured, are shown in Fig. 5, compared with the precipitation map of the Ulugurus (Fig. 6, original, published also in PÓCS, 1976/a). Finally, for the better interpretation, and for comparison,

an other selection of diagrams was made from different parts and vegetation zones of the country (Fig. 8).

From the transects shown and from the vegetation map of the Ulugurus (Pócs, 1975), several interesting facts can be drawn and some problems extracted:

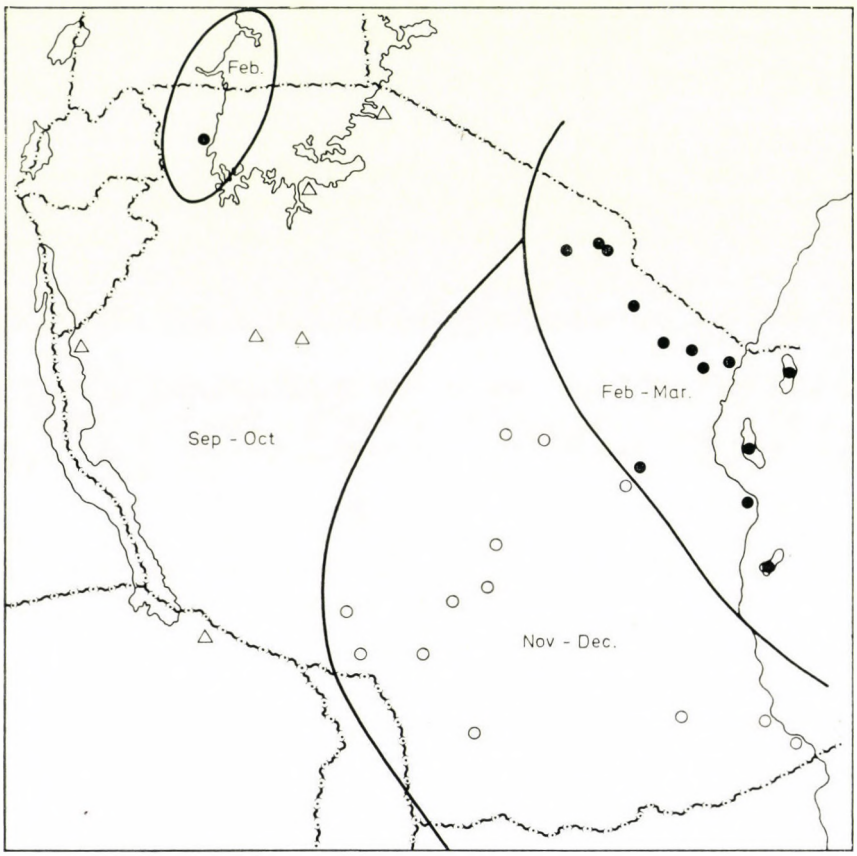


Fig. 4. The warmest month of the year in Tanzania

1. The eastern slopes exposed to rain-carrying winds, and the lee side of the mountains show a very asymmetric pattern of vegetational distribution. On the one hand, the vegetation zones descend deeper on the eastern than on the western side, on the other hand, there are plant communities which dominate the eastern, and others which better developed on the western, slopes. On the eastern slopes, there is practically no dry season, therefore, in natural circumstances the evergreen forests descend to the foothills. On the western side, the natural boundary of evergreen forests lies much higher, and the sub-

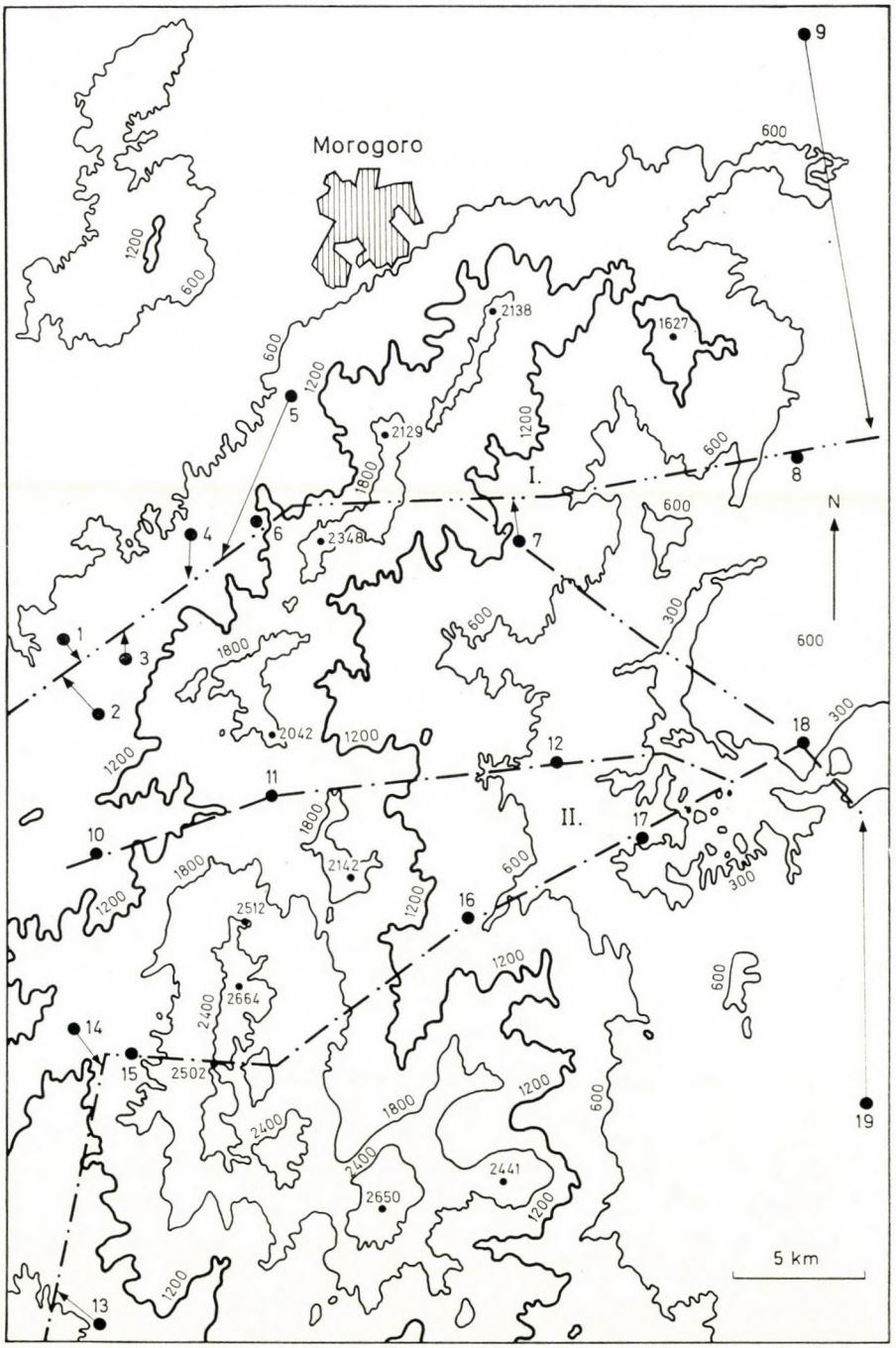


Fig. 5. Relief map of the Uluguru Mountains, with the indication of the site of vegetation transects and location of diagrammed rainfall stations

montane forests, which dominate the eastern slopes are substituted by dry forests and by deciduous woodland. This is the situation everywhere in the mountains where the dry season is longer than 1.5 months. Therefore the remnants of evergreen forests are good indicators of a climate practically without dry seasons.

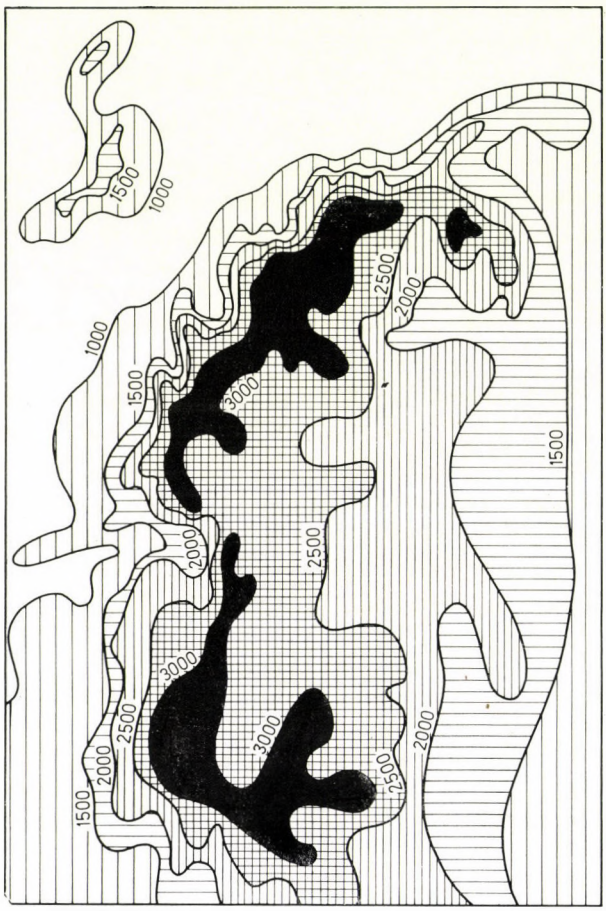


Fig. 6. Mean annual rainfall map of the Uluguru Mountains

2. There is no climatic evidence of the presence of a natural treeless vegetation in the mountains. Most probably all savannalike plant communities and a great part of the woodland area are derivates of dry semievergreen or of dry deciduous forests, for which the duration of a 2—6 months long dry season with 800—1300 mm annual rainfall cannot be an excluding factor. Only where the duration of the dry season is longer than half a year, does there

develop a natural wooded *Acacia* grassland (savanna), north- and westwards from the Ulugurus. The presence of relic forest patches (WINGFIELD, 1975; PÓCS, 1975) in the concerned zones on the western slopes underlines this fact. The valley grasslands are also not climatic communities (see VESEY-FITZGERALD, 1970).

3. A natural upper limit of high forests exists in the Uluguru Mountains. This lies in the more oceanic and more isolated northern part at about 2100 m while in the southern half of the mountains at about 2450 m altitude, where the forest gives place to either dwarf elfin woodland (PÓCS, 1974) or to bamboo thickets or (on tha Lukwangule Plateau) to subalpine spring bogs and moorlands, although a great part of the grassland on the Plateau is secondary (PÓCS, 1976/a). I consider this forest line in the Ulugurus in most cases a climatic one. As it is shown in the graph, the absolute minimum can fall well below zero at this altitude. Among other conditions, like on Mt. Kilimanjaro, the frost line and the forest line lie much higher, between 2600 and 3250 m respectively (see HEDBERG, 1951: 165, 186). No doubt, the frost at the altitudes of Uluguru Mts. is still not a diurnal phenomenon, but I observed obvious frost phenomena seriously damaging the montane forest vegetation, especially the tree ferns, as low as at 1800 m altitude ! (See Fig. 13). The elfin woodland and heath vegetation can occur below the upper limit of high forests, but this is usually the result of special circumstances, as severe soil conditions, or very strong winds (BAYNTON, 1969, telescoping effect of VAN STEENIS, 1972), similarly to the appearence of subalpine *Pinus mugho* scrub at low altitudes in the Central European Mountains ("Gipfelphenomän"). The elfin forests of the Uluguru Mountains are analogues of that of Indomalaysia and in many aspects similar to the giant heath (subalpine *Erica arborea* forest) of Mt. Kilimanjaro.

4. "Mossy" types of forests and woodlands develop at very different altitudes (from 800 up to 2500 metres) in the Ulugurus, due to continuous cloud formation. These mist-effected woodlands or forests covered by very large amount of epiphytic bryophytes and lichens are good indicators of the continuous high air humdity.

These mossy forests and woodlands play a "buffering" role in the water balance (PÓCS, 1976/b). Often, due to the turbulence of winds, the most humid mossy forests are on the lee side of sharp ridges, and summits, where the uppermost part remains drier than the slopes below.

5. The presence or absence of the giant African bamboo *(Arundinaria alpina)* cannot be interpreted merely by the actual climatic conditions. Althought it descends in the Ulugurus to the lowest point in East Africa (Mgeta valley at 1630 m altitude), its occurrence represents a disjunct pattern with very isolated patches. This fact suggests a possible retreat of the species here. The only locality in the northern part is the very steep eastern face of

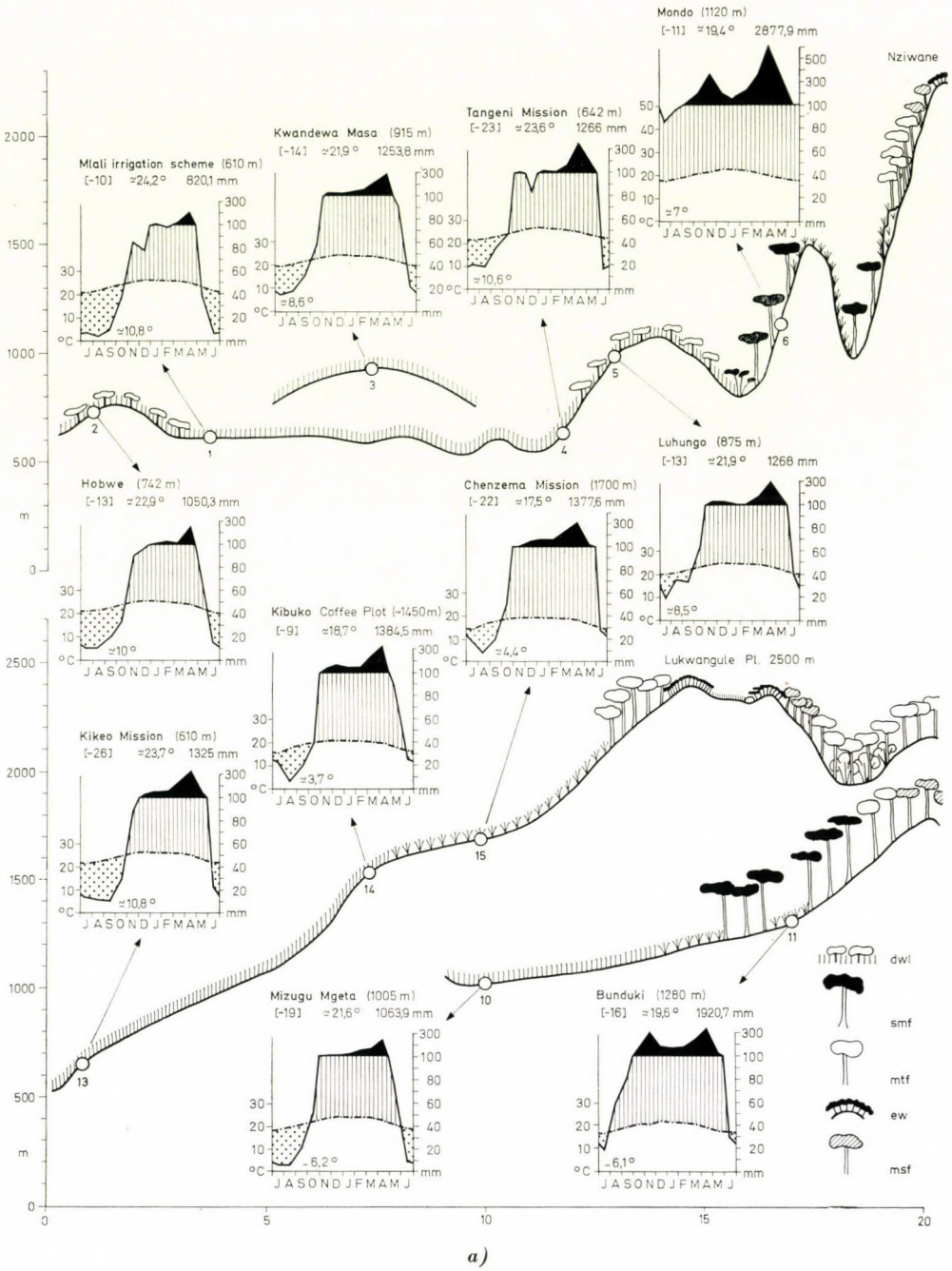
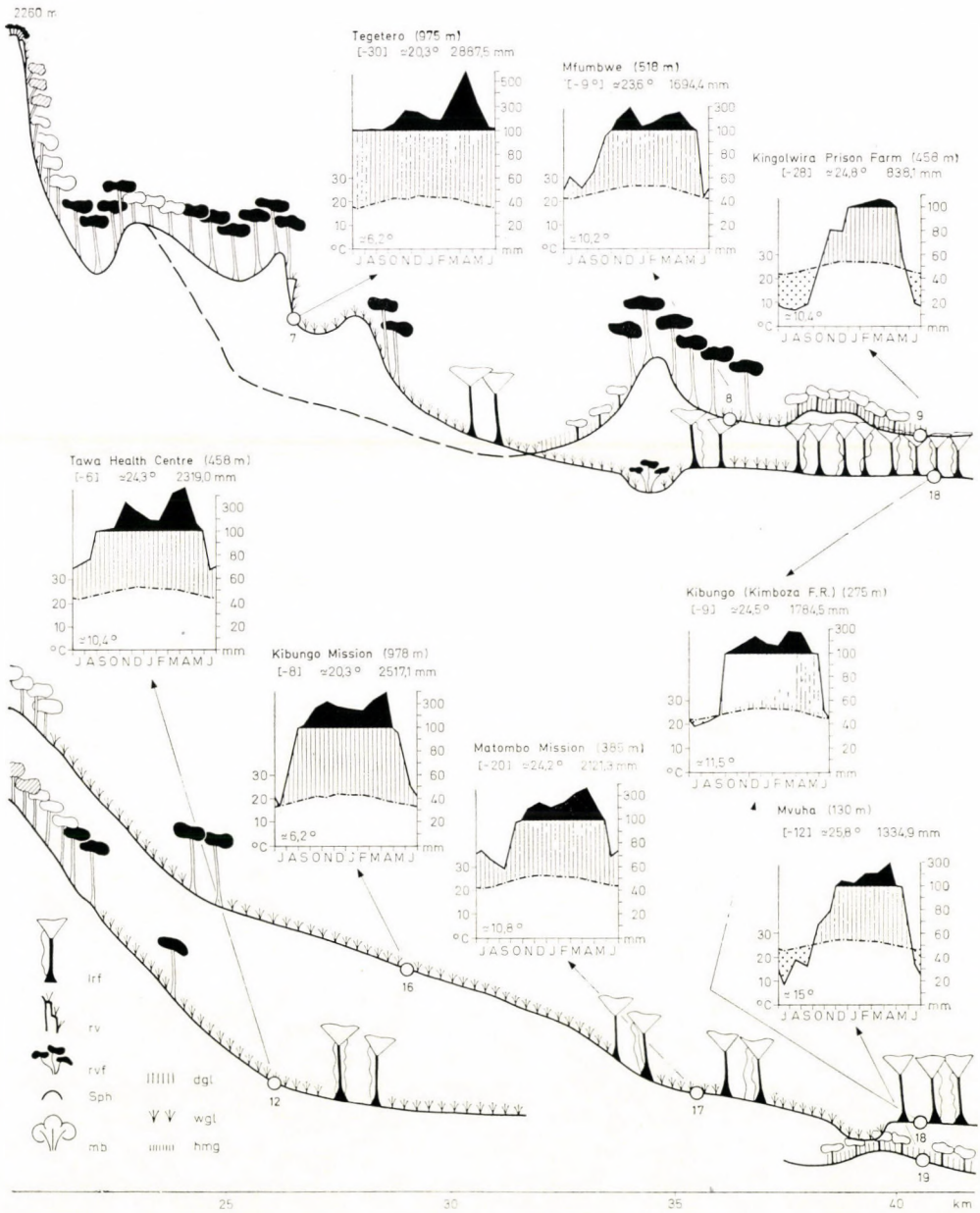


Fig. 7. Vegetation transects through the Uluguru Mountains. The upper one is made through the northern part, the lower one through the southern part. The GAUSSEN—WALTER climatic diagrams bear the same Nos, as in the map of Fig. 5; dwl: dry woodland, smf: submontane forest, mtf: montane forest, msf: montane mossy forest, ew: elfin woodland, lrf: lowland rain



b)

forest, rv: rock vegetation, dgl: dry grasslands replacing woodlands, wgl: wet grasslands replacing forests, rvf: riverine forest, hmg: high montane short grassland replacing elfin woodland, Sph: *Sphagnum* bog, mb: occurrence of montane bamboo (The horizontal—vertical ratio of the transect is 1 : 5.)

the Magari peak between 2150 and 2250 metres. In the southern Ulugurus, there is a very small patch of bamboo stand at the western edge of the Lukwangule plateau; there are very many tall bamboos in the Mgeta river valley from 1630 up to 2300 metres, intermixed with the trees of the montane broad-leaved forest; finally it forms pure thickets on the 2650 m high summit of Kimhandu, where it completely substitutes the elfin woodland.

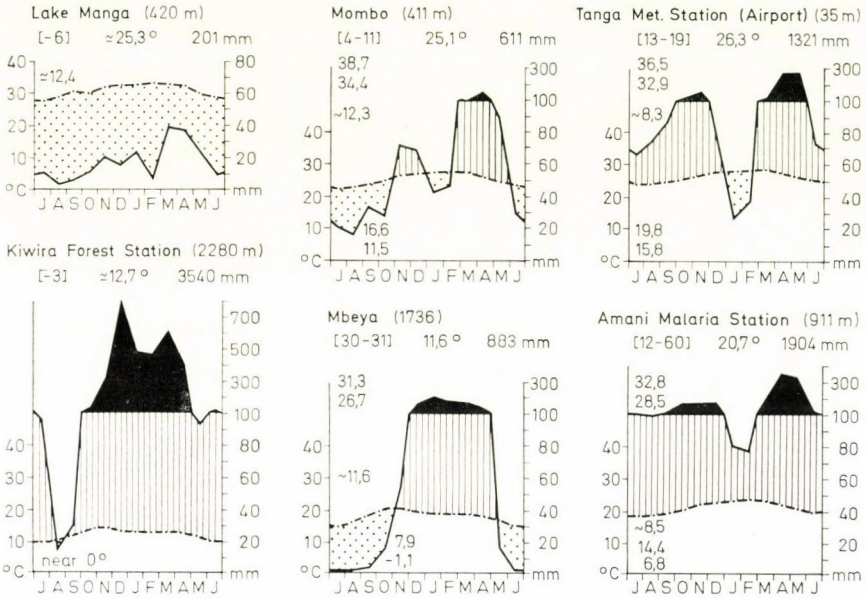


Fig. 8. Selected GAUSSEN—WALTER diagrams, representing different climates and vegetation zones in Tanzania. (When the temperature curve was prepared by the above method of extrapolation, the place of the number of years when temperature should have been measured is empty between the brackets.) Manga: Semidesert. Lowest measured rainfall in Tanzania. Mombo: Dry thicket rich in succulents. Tanga: Semievergreen coastal forest. Kiwira Forest Station: Typical montane rain forest. Highest measured amount of rainfall in Tanzania. Mbeya: Miombo *(Brachystegia-Isoberlinia)* woodland. Amani: Submontane rain forest

6. A wide range of vegetation communities, and first of all most types of closed forests or their remnants, are climatically induced and therefore good indicators of climatic conditions for Agriculture and for Forestry. On the other hand, the human influence on the Ulugurus is quite important. A series of vegetation types, although not used directly for agricultural purposes, is secondary derivate of other communities. These are, among others, the montane grasslands, in some case the miombo (*Brachystegia—Isoberlinia*) woodland, and in most cases the common slope woodlands (*Pterocarpus—Combretum*) on the northern, western and on the southerns slopes.

Conclusions

The following, climatically induced, altitudinal zonation can be established in the Uluguru Mountains, see (Fig. 9).

A. Low altitude dry forest and savanna woodland zone. Only at the western and northern foot of the Ulugurus, below 600 m altitude. Annual rainfall between 700—900 mm, the dry period lasts for 4—6 months. Main annual temperature 24—26°C. The whole area is densely cultivated, therefore only small remnants of the original vegetation can be detected.

B. Lowland semievergreen rain forest zone between 250—500 m altitudes at the eastern foothills of the central part of the mountains. Annual rainfall 1700—2400 mm, no dry season or maximum 1—2 month, main annual temperature 24—25°C. On the limestone ground of a carst plateau, including the Kimboza Forest Reserve, the lowland rain forest exists even through a 2.5 months long dry season.

C. Submontane dry forest and miombo woodland zone. Actually mostly replaced by an open woodland of *Pterocarya angolensis*, *Combretum* and *Terminalia* species, or by dry secondary grassland. On the eastern foothills, only on drier slopes, up to 800 m altitude. Widespread on the western, northern and southern slopes, as high up as 1500 m in the northern, and up to 1600—1700 m in the southern Ulugurus. With 950—1300 mm annual precipitation, 2—6 months dry season and 19—23°C main annual temperature. These communities suffer the most from the bush and grass fires.

D. Submontane evergreen and semievergreen forest zone. Contiguous belt on the eastern slopes, between 500 and 1500 metres, except in places used for agriculture. They occur in small patches also on the western side, in protected valleys at the lower edge of the evergreen forest belt. The submontane rain forests show the optimum of forest growth in East Africa. The average of rainfall is well over 1800 mm a year, usually exceeding 2500 mm and in some cases higher than 3000 mm, without being interrupted by a dry season. The main annual temperature lies between 23 and 17°C, at the lower and upper limits of this zone.

E. Montane evergreen forest zone. It forms a broad belt around both sides of the Mountains. The montane forest remained in relatively good condition, most of them falling inside the protected forest area. Their altitudinal limits are 1500—2100 m in the North and 1600—2400 m in the South. The annual precipitation varies locally between 1300 and (more than) 3000 mm. Especially the upper edge

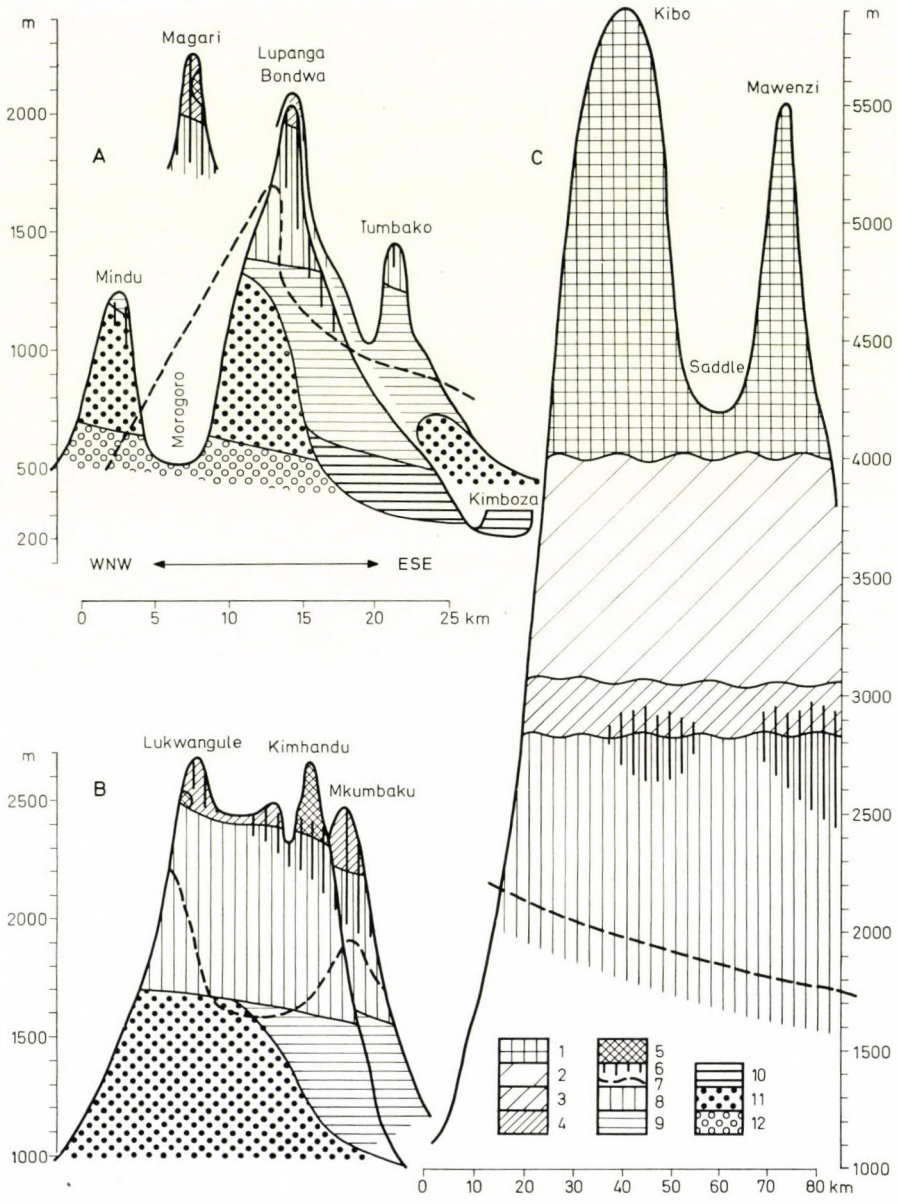


Fig. 9a. The vegetation zones of the Uluguru Mountains. Northern part (upper diagram) and southern part (lower diagram). The altitudinal zonation of Mt. Kilimanjaro is shown on the right in the same scale, based on HEDBERG (1951: 165). 1: Alpine zone 2: Subalpine ericaceous shrub zone 3: Subalpine moorland and *Erica arborea* forest zone 4: Subalpine or upper montane elfin forest zone 5: Bamboo thickets 6—7: Mist-effected "mossy" types, and the upper limit of cultivation 8: Montane evergreen forest zone 9: Submontane evergreen forest zone 10: Lowland rain forest zone 11: Submontane dry forest and woodland zone 12: Lowland dry forest and savanna woodland zone

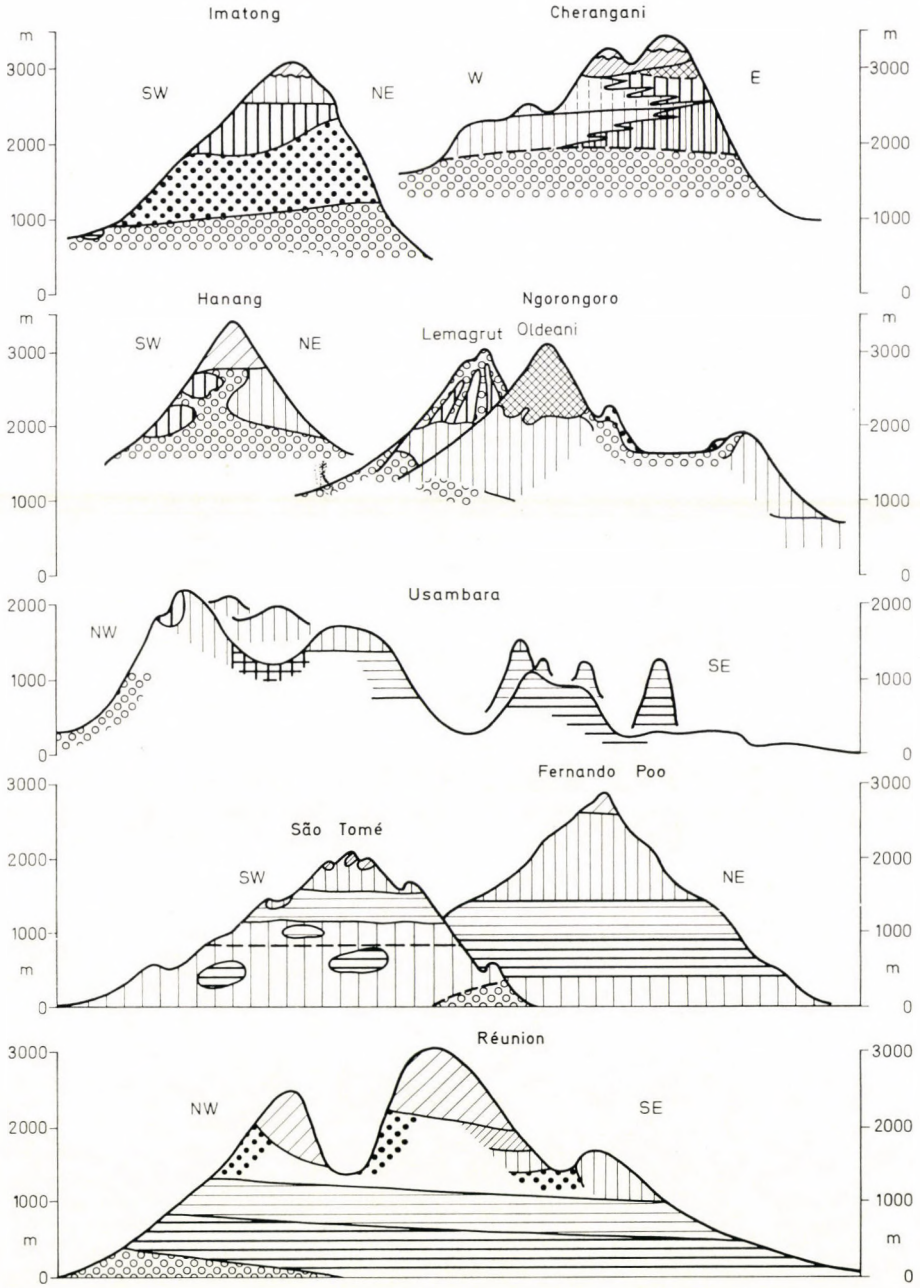


Fig. 9b. Vegetation zonation in some african mountain areas of medium altitude, from the continental types (above) to the oceanic ones (below). Explanation of the symbols the same as on Fig. 9*a*. (Based partly on JACKSON 1956, MABBERLEY 1975, GREENWAY 1955, MOREAU 1935, MONOD 1960, RIVALS in KNAPP 1973, partly original.)

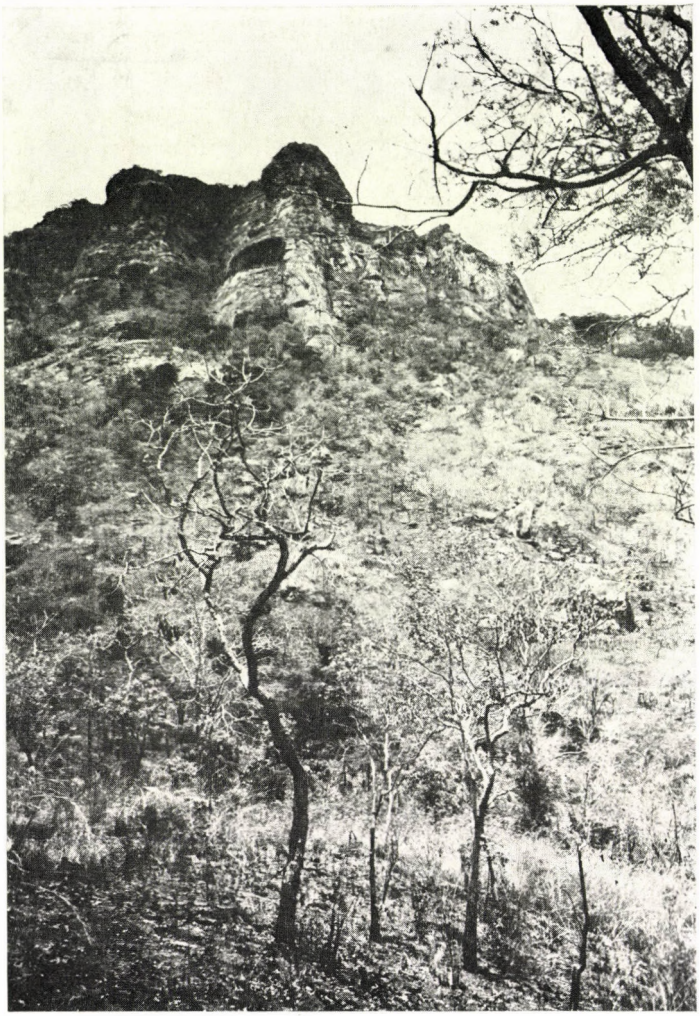


Fig. 10. Dry woodland vegetation on the NE slope of Nguru ya Ndege hill, 700—1200 m

of this zone receives a high amount of rainfall without a seasonal interruption, or even if short dry periods occur, they are compensated by the contiguous cloud and mist formation at this altitude. Main annual temperature: 12—17°C. The diurnal change of temperature is very low (when measured, it was only 4°C), and occasional frost occurs.

F. Upper montane or lower subalpine zone with elfin woodlands, bamboo thickets, peat bogs and with secondary grasslands, above altitudes 2100—2400 m. Although the annual variation of temperature is

Fig. 11. Lowland rain forest on dolomitic marble; carst plateau of Kimboza Forest Reserve at the E foothills, 300 m altitude above sea level

low, the diurnal change becomes much higher than in the high forest zones, reaching more than 15°C, and it often sinks below or near zero. The dwarf and very closed canopy of the elfin forest is a good adaptation against the strong reradiation during cool nights when the cloud belt usually sinks down and the high summits of the Ulugurus remain exposed.

Fig. 12. Submontane rain forest on the SE slope of Mt. Tumbako, 900—1300 m

Fig. 13. Tree ferns damaged by frost in the montane forest of Mt. Kifigo, 1800 m

Fig. 14. The north slopes of Magari peak, covered by montane forests and by elfin woodland, 1600—2340 m

Fig. 15. Montane rain forest near Hululu Falls, south of Bunduki, at 1500 m altitude. In the foreground dragon trees *(Dracaena steudnerii)*, in the background tree ferns

Fig. 16. Seminatural grasslands and forest line on the Lukvangule Plateau at 2450 m altitude, with scattered *Agauria salicifolia* trees. In the background the highest point of the Ulugurus, the 2664 m high Lukwangule peak, can be seen

Fig. 17. Elfin forest at the edge of Lukwangule Plateau, at 2450 m. The very dense canopy of the dwarf (2—4 m tall) trees is to be noticed

ACKNOWLEDGEMENTS

The author expresses his gratitudes to the Research and Publication Committee of the University of Dar es Salaam for sponsoring his field works, to his assistants Messrs. P. S. MWANJABE and M. LUNG'WECHA, who accompanied and helped him during this study and finally towards Mrs. H. MUHORAY for the fine line drawings.

REFERENCES

(Does not contain most works enumerated in the Part I of this series.)

BORHIDI A. (1974): Kubában térképeztünk. Gondolat, Budapest, 241 pp.

BURTT, B. D. (1942): Some East African vegetation communities. Edited by C. H. N. JACKSON. J. Ecol. **30,** 65—146.

CHAPMAN, J. D.—WHITE, F. (1970): The evergreen forests of Malawi. Commonwealth Forestry Institute, Oxford, 190 pp. + 60 pl.

COE, M. J. (1967): The ecology of the alpine zone of Mount Kenya. Dr. W. JUNK, The Hague, 136 pp.

COETZEE, B. J.—WERGER, M. J. A. (1975): A west-east vegetation transect through Africa south of the Tropic of Capricorn. Bothalia **11,** 539—560.

East African Meteorological Department (1959): Temperature data for stations in East Africa. Part I. Kenya. E.A.C.S.O. Nairobi.

East Afr. Met. Dept. (1964): Climatological statistics for East Africa and Seychelles. Part III. Tanganyika & Zanzibar. E.A.C.S.O. Nairobi, 76 pp.

East Afr. Met. Dept. (1971): Summary of rainfall in Tanzania for the year 1969. E.A.C. Nairobi, 33 pp.

GILLI, A. (1975): Pflanzensoziologische Beobachtungen aus Ostafrika. Feddes Rep. **86,** 233—252.

HÄMET-AHTI, L.—AHTI, T.—KOPONEN, T. (1974): A scheme of vegetation zones for Japan and adjacent regions. Ann. Bot. Fennici **11,** 59—68.

HEDBERG, O. (1951): Vegetation belts of the East African mountains. Svensk Bot. Tid. **45,** 140—202 + 6 pl.

HEDBERG, O. (1964): Features of afroalpine plant ecology. ALMQVIST & WIKSELLS, Uppsala, 144 pp.

HOPKINS, B. (1965): Forest and savanna. An introduction to tropical plant ecology with special reference to West Africa. Heinemann, Ibadan and London, 100 pp.

JACKSON, I. J. (1970): Rainfall over the Ruvu Basin and surrounding area. B.R.A.L.U.P., Dar es Salaam, litogr., 11 pp + 20 figs.

KENWORTHY, J. J. (1966): Temperature conditions in the tropical highland climates of East Africa. E. A. Geogr. Rev. **4,** 1—11.

KLOTZ, G. (1965): Beiträge zur Flora und Vegetation Indiens I. Wiss. Z. Univ. Halle **XV-66,** 97—148.

KNAPP, R. (1973): Die Vegetation von Afrika unter Berücksichtigung von Umwelt, Entwicklung, Wirtschaft, Agrar- und Forstgeographie. The vegetation of Africa with references to environment, development, economy, agriculture and forestry geography. Gustav Fischer, Jena, 626 pp.

LEWALLE, J. (1972): Les étages de végétation du Burundi occidental. Trav. Univ. Off. Bujumbura C. Fac. Sc. No. **20,** 173 pp + plates.

LIND, E. M.—MORRISON, M. E. S. (1974): East African vegetation. Longman, London, 257 pp.

LONGMAN, K. A.—JENIK, J. (1974): Tropical forest and its environment. Longman, London, 196 pp.

MOREAU, R. E. (1935): A synecological study of Usambara, Tanganyika Territory. J. Ecol. **21,** 1—43.

PHILIPS, J. (1930): Some important vegetation communities in the central province of Tanganyika Territory (formerly German East Africa). J. Ecol. **18,** 193—234.

PÓCS, T. (1974): Bioclimatic studies in the Uluguru Mountains (Tanzania, East Africa) I. Acta Bot. Acad. Sc. Hung. **20,** 115—135.

PÓCS, T. (1975): Vegetation map of the northern Uluguru Mountains, East Africa, Tanzania. Conservatoire et Jardin Botaniques, Genève, 1 sheet.

PÓCS, T. (1976a): Vegetation mapping in the Uluguru Mountains (Tanzania, East Africa). Boissiera **24ő,** 477—498.

PÓCS, T. (1976b): The rôle of the epiphytic vegetation in the water balance and humus production of the rain forests of the Uluguru Mountains, East Africa. Boissiera **24b,** 499—503.

PORTER, PH. W. (1973): A pilot study to determinate the feasibility of creating a new vegetation map of Tanzania. B.R.A.L.U.P. Res. Report **4/2,,** Dar es Salaam, litogr. 17 pp.

SCOTT, J. D. (1934): Ecology of certain plant communities of the Central Province, Tanganyika Territory. J. Ecol. **22,** 177—229.

TROLL, C. (1967): Die klimatische und vegetationsgeographische Gliederung des Himalaya-Systems. Khumbu Himal **1,** 353—448.

VESEY-FITZGERALD, D. F. (1970): The origin and distribution of valley grasslands in East Africa. J. Ecol. **58,** 51—75.

VAN STEENIS, C. G. J. (1972): The mountain flora of Java. Introduction. E. J. Brill, Leiden p. 1—80.

WELCH, J. R. (1960): Observations on deciduous woodland in the Eastern Province of Tanganyika. J. Ecol. **48,** 557—573.

WINGFIELD, R. (1975): Annotated list of plants growing on the University Agriculture & Forestry Faculty Campus, Morogoro, ed. 3, with introduction, map & index. Stenciled manuscript. 15 pp.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1—2), pp. 185—200 (1976)

STUDIES ON THE GROWTH ANALYSIS OF MAIZE HYBRIDS (OSSK-218 AND DKXL-342)

By

I. PRÉCSÉNYI,[1] GY. CZIMBER,[2] G. CSALA,[3] Z. SZŐCS,[1] E. MOLNÁR[1] and E. MELKÓ[1]

[1] HAS RESEARCH INSTITUTE FOR BOTANY, VÁCRÁTÓT; [2] KESZTHELY UNIVERSITY OF AGRICULTURAL SCIENCES; DEPARTMENT OF BOTANY AND PLANT PHYSIOLOGY, MOSONMAGYARÓVÁR; [3] AGRICULTURAL COMBINE, BÁBOLNA

(Received January 9, 1976)

The paper deals with the growth analysis of two maize hybrids (OSSK-218 and DKXL-342). The investigations were carried out in maize grown under factory conditions (Agricultural Combine, Bábolna), between May 22 and August 15, 1974, from the 6th week to the 16th week of age. The weight of above-ground parts and leaf area were measured in two-week periods. For the description of growth in weight and of leaf area, the exponential equation was used. On the basis of the equation, the weight and leaf area of a plant were determined for every week. In the possession of these data, the RGR, NAR, LAR, RLGR and CGR as well as the efficiency values were estimated for every week. The study also deals with the changes in the growth characteristics of hybrids mentioned above. The relationships between the various climatic factors (weekly mean temperature, weekly amount of rainfall, observed weekly total hours of the duration of sunshine) and the growth characteristics as well as the correlations between the growth characteristics themselves are analyzed. Finally, the effect of climatic factors on the variability of the growth characteristics and the influence of growth characteristics on RGR variability are discussed.

Growth analysis is a method which can be used as an approach in the examination of plant photosynthetic production. The result of net assimilation taking place in the plant is considered as net production (NP = NA — D = =(GA — R) — D; NP = net production, NA = net assimilation, D = decay, GA = gross assimilation, R = respiration).

According to KVĚT—ONDOK—NEČAS—JARVIS (1971), growth analysis is employed in two directions: (i) examination of the relationships between the productive capacity of a plant genotype and the internal factors; (ii) investigations of production and growth influenced by environmental factors.

The daily rate of growth (relative growth rate, RGR) is determined by two parameters (if no special mention is made of the kind of growth, for example of leaf area, then weight gain is meant): the daily net efficiency of the assimilation per unit of assimilatory surface (net assimilation rate, NAR) and the relationship of the total assimilatory surface to the weight of the whole plant (leaf area ratio, LAR), writes BLACKMAN (1968). Of the two parameters, the first contains a physiological, the second a morphological meaning (EVANS 1972). In the knowledge of relative growth rate and of leaf area ratio, the net assimilation rate can be assessed.

Relative growth rate is not constant during plant life, therefore, a good approximation can be achieved only if samples are taken frequently, in short intervals (BRIGGS—KIDD—WEST, 1920). Since the relative growth rate is formed by the net assimilation rate and because the leaf area ratio and the latter decreases from a certain time point of development, the net assimilation rate has a great role in the formation of the relative growth rate.

The subject of our study is the growth analysis of two maize hybrids (OSSK-218 and DKXL-342), grown in the area of the Agricultural Combine, Bábolna, in 1974.

Material and method

The measurements were made on individuals grown in factory conditions. The above-ground plant parts were considered.

1. Characterization of the hybrids: OSSK-218, Yugoslavian hybrid; FAO number: 460. A hybrid permitted to be marketed in 1970. A two-line hybrid grown from the hybridization of two inbred lines. Its stalk has a dark-green colour and medium width. It has no offshoots. Its leaf is dark-green, large, and lanceolate. The tassel is loose of medium size. The colour of the anthers is green. Spaced sparsely, is inclined to have two cobs. The peduncle of the cob is long, therefore in ripening the cob is abaxial. The cob is cylindrical, the kernel flattened, its colour yellow. The colour of the ear is red. Ratio of kernel/ear: 84/16. The hybrid is of excellent stalk strength, thus it is suitable for mechanized harvesting. Growing period is 145—148 days. Medium to early ripening, at about the end of September. Moderately sensitive to infection by strumous smut, fibroid smut, European corn-borer and also to damages caused by them. It is resistant to *Fusarium*. The hybrid was produced in the State Farm of Bóly, in 1974.

Dekalb XL-342 (DKXL) American hybrid maize; FAO number: 580. Quality degree: a variety permitted to be marketed in 1970. The three-line hybrid has been produced by the hybridization of three inbred lines, in the USA and in Italy. Its stalk is very high (270—300 cm), thick, dark-green and of large, vivid green leaves, without offshoots. It develops one thick and long cob. The cob is at the same height in all plants. The cob is cylindrical, with a medium long peduncle. The cob is well-covered with husks. The kernel is flat and large, of a light-yellow colour. The kernel/ear ratio is 84/16. The growth period is 156—160 days. The hybrid is of late ripening and of excellent productivity. Its stalk strength is very good. Resistant to diseases. Not sensitive to damages by the European corn borer. Optimal plant density is 46—50,000 plants/ha. In 1974, Italian-produced seed was sown in the area of the Combine.

2. Workshop conditions: in the maize area of the Combine, the industry-like production of maize takes place in monocultures.

Since 1960, weed-killing has been carried out by chemical control. The herbicides used in the maize fields from which the plants were gathered in 1974 are listed in Table 1, where also the more important economical data are to be found.

3. The characterization of soil conditions is given in Table 2, containing the results of the analysis of soil samples taken on May 22, 1974.

4. Climatic conditions: on the basis of field observations, the climatic conditions of the vegetation period are shown in Table 3.

5. Sampling: 10 or 5 plants were cut at each sampling (May 22, June 5 and 19, July 3, 18 and 31, August 15). Sampling began on the fifth week after sowing, when the plants were in their four-leaf state. Table 4 shows the maturity of stands on July 31, 1974. The dry weight of the plant, the length of the leaves and their largest width were measured in the laboratory. The average was used in the calculations. The weight of the under ground plant parts was not measured. Neither was the stalk width, therefore the method suggested by GIOVANARDI (1972) was not used for the assessment of the total assimilatory surface.

6. Calculation of leaf-area: the equation $LA = (\text{length}) \times (\text{largest width}) \times 0.74$ was used for the calculation of leaf-area (KEMP, 1960). The multiplier 0.74 was determined on the basis of samples. This value is within the limits given in the literature (KVĚT—MARSHALL, 1971).

Table 1

The main economic data

	Symbol of the hybrid	
	OSSK-218	DKXL-342
Place and number of field	B 8	Ba 15
Years of monoculture	9	4
Herbicide	Oleo-Hungazin	Aktikon PK
Sowing time	April 15—23	April 22—23
Number of plants, plant/ha	62,000	58,000
Crop* average, q/ha	64.6	79.8

* Eared; B = Bábolna, Ba = Bana

Table 2

Results of soil analysis
(May 22, 1974)

Place and number of field	pH		y_1	Humus, %	Easily soluble		Total N%	Carbonic chalk, %	Arany's binding number
	in water	KCl			P_2O_5 mg/100 g	K_2O mg/100g			
B 8	7.35	7.20	3.50	6.35	22.5	10.8	0.18	0.12	33.8
Ba 15	7.60	7.60	1.50	5.29	12.8	11.2	0.19	5.89	39.0

Table 3

Meteorological data
(Bábolna, 1974)

Month	Average temperature (°C)	Deviation from the 50 years' average	Amount of precipitation (mm)	Deviation from the 50 years' average	Amount of the monthly total hours of sunshine	Deviation from the 50 years' average
III.	7.7	+2.2	5.1	−34.9		
IV.	11.0	+0.5	28.9	−19.1		
V.	14.6	−1.2	76.4	+14.4	75*	
VI.	17.6	−1.8	73.9	+14.9	184	−72
VII.	20.3	−1.1	36.3	−27.7	208	−78
VIII.	22.4	+1.8	95.3	+31.3	214	−52

* Data measured beginning with May 21

7. Description of the growth (weight and leaf area): for this, the equation

$$X_1 = X_0 e^{kt}$$

was used (BRODY, 1945). The weight and leaf area of a plant were calculated for each day between the individual samplings, by the assumption that the value of exponent k does not

Table 4

Growth phase of stands
(July 31, 1974)

Symbol for the hybrid	Place and number of the field	Tasseling	Pistillate flowering	Average height (cm)	
		%		July 24, 1974	August 15, 1974
OSSK-218	B 8	90	75	180	227
DKXL-342	Ba 15	5	=	175	244

essentially change between two samplings. On the basis of the weight and leaf area values calculated per day, the characteristics used in the growth analysis (see later) were determined for every week. The first and last (incomplete) weeks were left out of considerations (May, 22—25 and August, 11—15).

8. Characteristics examined: the method used here was taken from the works of BRIGGS—KIDD—WEST (1920), KVĚT—ONDOK—NEČAS—JARVIS (1971) and EVANS (1972). The characteristics are as follows: CGR = crop growth rate (= productivity, ODUM, 1971); RGR = relative growth rate (= efficiency index, BLACKMAN, 1919; cit. in: KVĚT—ONDOK—NEČAS—JARVIS, 1971; = instantaneous relative growth rate, BRODY, 1945); RLGR = relative leaf growth rate; NAR = net assimilation rate (= unit leaf rate, EVANS, 1972); LAR = leaf area ratio; efficiency = the capability of the plant to solar energy conversion. The calculation of efficiency was carried out as follows: weight gain and increase of leaf surface per day were calculated. The daily total hours of the duration of sunshine were known for every day. With these data and on the basis of the equation

$$Q = (0.22 + 0.52\ n/N)Q_0$$

the daily total amount of incoming solar radiation was calculated as cal./cm²/day. The equation was taken from the work of MITSUDERA—SAKAI (1975) and DURAND (1974). The coefficient of the equation given by DURAND hardly differs from the values given in the publication of MITSUDERA—SAKAI. The latter values agree with the average of the values contained in Table 1 of DURAND. In the above equation, n = observed daily total hours of sunshine duration; N = maximum possible amount of the daily total hours of sunshine; Q = daily total amount of solar radiation falling on a horizontal surface of the earth; Q_0 = daily total amount of global solar radiation outside of the atmosphere.

Half of the Q value was used in the calculation, since only about half of the incoming solar radiation falls on the interval which is converted by the plants (PAR). Having these data, we calculated the incoming solar radiation failing on the leaf surface at time t_0, and the amount of weight gain between the points of time $t_1 - t_0$ (one day); this was multiplied by 4.00, which is an estimation of the calory value of the dry matter. Dividing the value of plant growth expressed in calory by the quantity of calory incoming on the leaf surface gives the efficiency (in our study, the result is given in percentages).

Results and evaluation

Weight gain

For the description of weight gain, we used the equation mentioned above. The value of k in the exponent was calculated by the equation

$$k = \ln (W_1/W_0) / (t_1 - t_0)$$

(BLACKMAN, 1919; FISHER, 1921; both cit. in: KVĚT—ONDOK—NEČAS—JARVIS, 1971; BRODY, 1945), which is the equivalent of RGR estimation.

Table 5

The change of RGR and RLGR in OSSK-218 and DKXL-342 hybrids

Sampling time	RGR (g/g/day)		RLGR (cm^2/cm^2/day)	
	OSSK	DKXL	OSSK	DKXL
1974. V. 22—VI. 5.	0.0685	0.1063	0.0858	0.1181
VI. 6—VI. 19.	0.1385	0.0762	0.1120	0.0716
VI. 20—VII. 3.	0.1003	0.1319	0.0867	0.1065
VII. 4—VII. 18.	0.1331	0.1164	0.0831	0.0775
VII. 19—VII. 31.	0.0331	0.0338	0.0011	0.0175
VIII. 1—VIII. 15.	0.0284	0.0281	—0.0027	0.0060

By using the RGR = k values given in Table 5, we calculated the daily weight of one plant. The curves shown in Fig. 1 are drawn on this basis. Beginning with the 13th week, the drop in weight gain of the hybrids is well observable. This is even more obvious if the logarithm of the weight is taken. Our system was to consider the weeks 6—13 as belonging to one curve, and those between 13—16 to another one. In the first phase the sixth week was taken as the first one, while the 13th week as the eight one; in the second phase the 13th week was the first and the 16th week was the fourth. The curves are shown in Fig. 1, their equations are given in Table 6. The regression coefficients

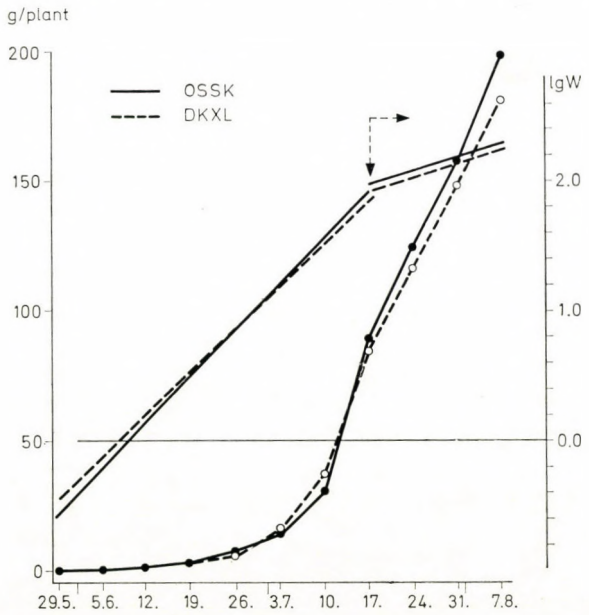


Fig. 1. The growth rate of the hybrids (for explanation see text)

Table 6

Weight gain of the hybrids (log W) *as a function of time (detailed explanation in text)*

Hybrid	Phase	Correlation coefficient (r)	Regression equation	n
OSSK-218	I.	0.996***	$\lg W_1 = 0.3565X_1 - 0.9417$	8
	II.	0.955*	$\lg W_2 = 0.1146X_2 + 1.8485$	4
DKXL-342	I.	0.996***	$\lg W_1 = 0.3295X_1 - 0.7621$	8
	II.	0.989*	$\lg W_2 = 0.1084X_2 + 1.8367$	4

* 5% level; ** 1% level; *** 0.1% level significant value (hereinafter the marks will be used with the same reference)

calculated for the two hybrids do not differ in any of the phases; in Phase I $t = 1.81$, in Phase II $t = 0.24$.

Table 7 contains the weights calculated and measured in three different ways. With the first and second methods, the observed and measured values can be assessed very well, while the third method resulted in less satisfactory estimation.

Table 7

Estimation of the hybrid weights (g/plant)

Sampling time	W_0	W_{e1}	W_{e2}	W_{e3}
Hybrid: OSSK-218				
VI. 5.	0.49	0.49	0.49	0.59
VI. 19.	3.47	3.46	3.41	3.05
VII. 3.	14.13	14.10	13.89	16.12
VII. 18.	104.00	103.81	102.28	91.85 (VII. 17.)
VII. 31.	160.00	159.63	157.28	155.70
Hybrid: DKXL-342				
VI. 5.	0.91	0.91	0.91	0.79
VI. 19.	2.64	2.64	2.64	3.60
VII. 3.	16.74	16.72	16.72	16.40
VII. 18.	96.00	95.84	95.86	88.12 (VII. 17.)
VII. 31.	149.00	148.75	148.75	145.20

W_0 = observed weight; $W_{e1} = W_0 e^{kt}$, calculated on the basis of $t = t_1 - t_0$; $W_{e2} = W_0 e^{kt}$ calculated on the basis of $t = 1$ day; W_{e3} is calculated on the basis of the equations given in Table 6

Leaf area growth rate

In the description of the leaf area growth rate our system was similar to that used in weight gain description. The RLGR values are given in Table 5. The curves drawn on the basis of leaf areas calculated for days are shown in Fig. 2. By drawing the logarithm of the leaf area, the break on the 13th week in the weight gain mentioned above is observable also here, therefore we give two equations (Table 8). It can be seen that in the case of OSSK the value of r is not significant in the second phase. The regression coefficients do not differ in any of the phases of the hybrids (Phase I: $t = 1.42$; Phase II: $t = 0.78$).

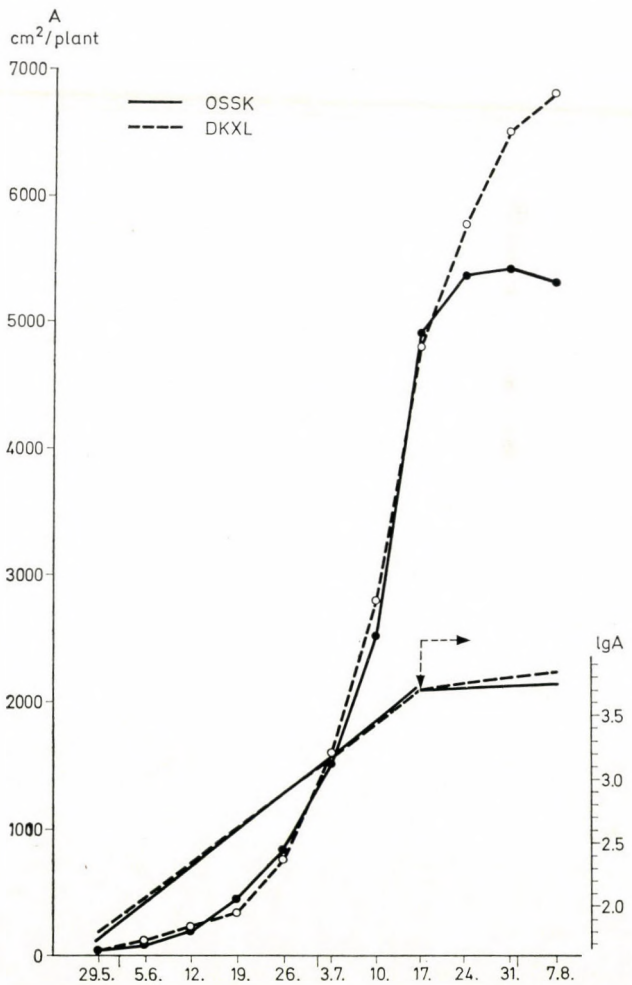


Fig. 2. The leaf area growth of the hybrids (see text)

Table 8

Growth of the leaf area of the hybrids (log A) *as a function of time*

Hybrid	Phase	Correlation coefficient (r)	Regression equation	n
OSSK-218	I	0.998***	$\lg A_1 = 0.2856X_1 + 1.4548$	8
	II	0.550	$\lg A_2 = 0.0110X_2 + 3.6925$	4
DKXL-342	I	0.998***	$\lg A_1 = 0.2727X_1 + 1.5229$	8
	II	0.956**	$\lg A_2 = 0.0506X_2 + 3.6465$	4

The leaf area values measured and estimated in three different ways are given in Table 9. The values obtained on the basis of equations involving logarithms differ very much from the observed values in the case of both hybrids.

Table 9

Estimation of the leaf area of the hybrids (cm²/plant)

Sampling time	W_0	W_{e1}	W_{e2}	W_{e3}*
Hybrid: OSSK-218				
VI. 5.	95.32	95.33	95.31	106.20
VI. 19.	457.28	457.33	457.33	395.50
VII. 3.	1538.5	1539.5	1539.1	1473.8
VII. 18.	5350.7	5354.5	5353.3	5023.0 (VII. 17)
VII. 31.	5429.3	5431.6	5430.4	5284.0
Hybrid: DKXL-342				
VI. 5.	134.54	134.58	134.60	117.07
VI. 19.	366.40	366.70	366.70	395.50
VII. 3.	1627.20	1628.80	1628.80	1473.80
VII. 18.	5204.50	5208.90	5208.70	5023.00 (VII. 17)
VII. 31.	6536.30	6539.50	6539.40	5284.00

References as in Table 7

A strong positive correlation exists between the logarithm of weight (W) and that of leaf area (A); see Fig. 3 (OSSK: r = 0.992***, lg A = 0.7225 lg W + 2.2293; DKXL: r = 0.988***, lg A = 0.7731 lg W + 2.1793).

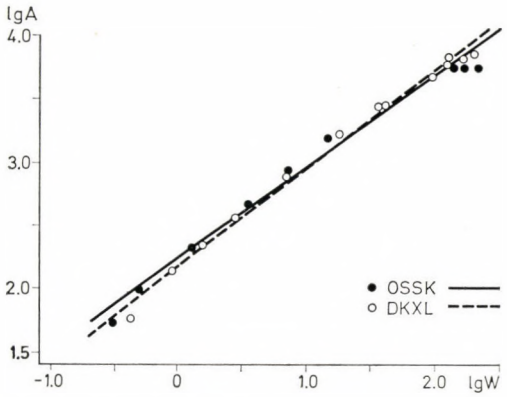


Fig. 3. Correlation between the logarithm of weight and of leaf area

Growth characteristics

a) The weekly change in the crop growth rate is of an identical tendency in hybrids up to the 14th week (Fig. 4). On the 15th and 16th weeks the productivity of DKXL rises, while that of OSSK drops, yet to a smaller extent than on the 14th week. From the 12th week, OSSK productivity surpasses DKXL productivity. However, on the 16th week the productivity of the two hybrids shows very close values. The maximum productivity on the 13th week is identical in the hybrids.

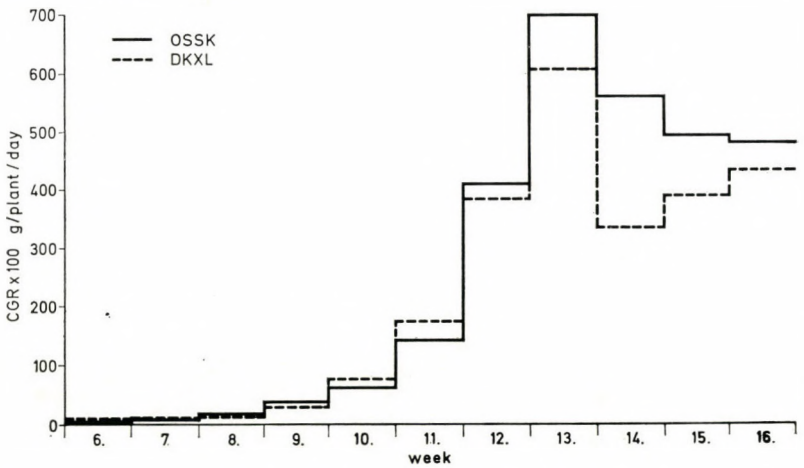


Fig. 4. Weekly CGR changes in the hybrids

b) Figure 5 shows the weekly changes in the relative growth rate of the hybrids. Until the 12th week, the RGR of the hybrids changes contrarily, then it decreases in both of them. The greatest decrease occurs on the 13th

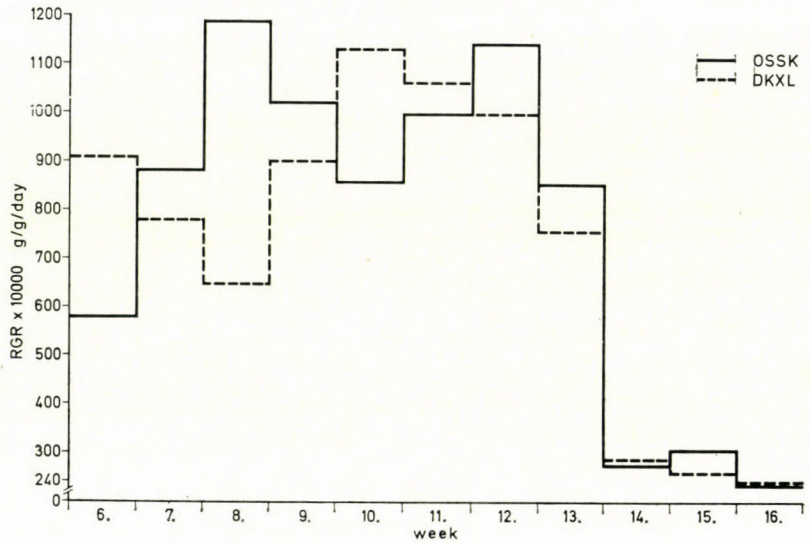


Fig. 5. Weekly RGR changes in the hybrids

week turning into the 14th week. During weeks 14—16, the RGR of the two hybrids is about identical.

c) The relative leaf growth rate (RLGR) is of a declining tendency already from the 10th week in the hybrids (Fig. 6). Until the 10th week, the RLGR changes oppositely in them. From the 11th week to the 14th week almost identical values emerge. The greatest drop occurs also with this characteristic on the turn of week 13 to 14. The relative leaf growth rate of OSSK

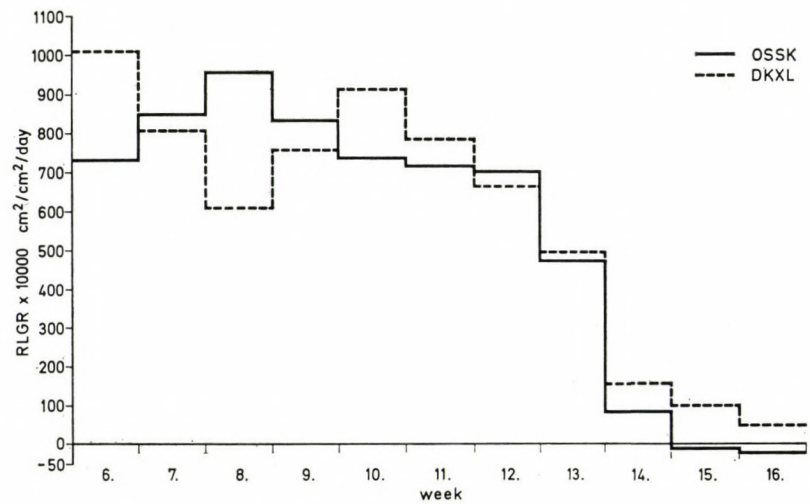


Fig. 6. Weekly RLGR changes in the hybrids

becomes negative on the 15th and 16th weeks, that is a reduction arises instead of growth. This phenomenon is in connection with the decaying of the lower leaves; around the end of July, the lower 3—4 leaves dry and fall off of the stalks.

d) The weekly changes in NAR showed a rising tendency in OSSK, between weeks 6—13. In DKXL the NAR value rose from the 8th week (Fig. 7), while in the 12th and 13th weeks it was about the same. The hybrids

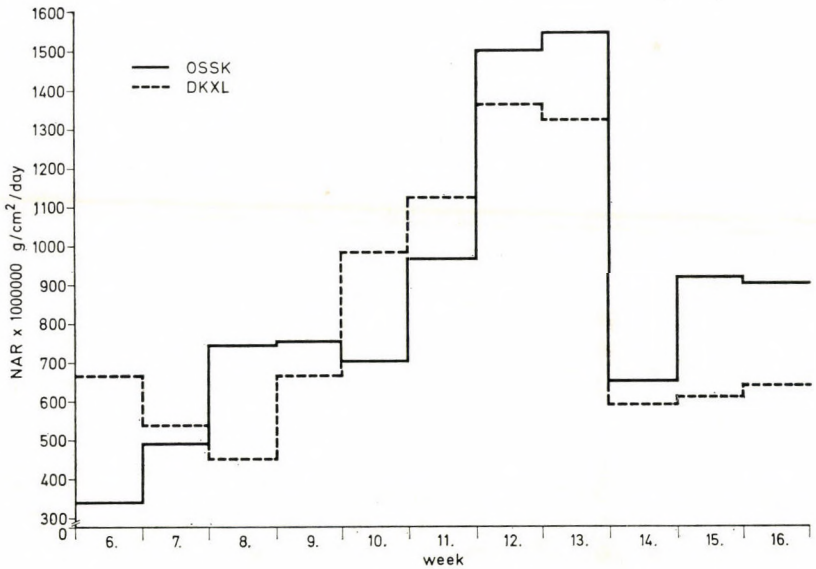


Fig. 7. Weekly NAR changes in the hybrids

had the greatest NAR value in the 12th and 13th weeks. By the follow ng week the NAR values of both hybrids dropped back to their halves, then they rose again on the 15th week.

e) Figure 8 shows the leaf area ratio. On the seventh week a maximum occurred in the hybrids, then the LAR values decreased until the end of examination.

f) The weekly changes in the efficiency percentages of the hybrids showed a similar tendency in almost all cases (Fig. 9). The highest values occurred on the 12th week. The values in the figure are the weekly average. The daily values exceed them or they are lower than the weekly values. The maximum OSSK estimated efficiency is 8.4% (July, 12), its minimum efficiency percentage is 0.6% (June, 4 and 5). The maximum estimated DKXL efficiency is 7.6% (July, 12), its minimum efficiency is 0.9% (June, 9).

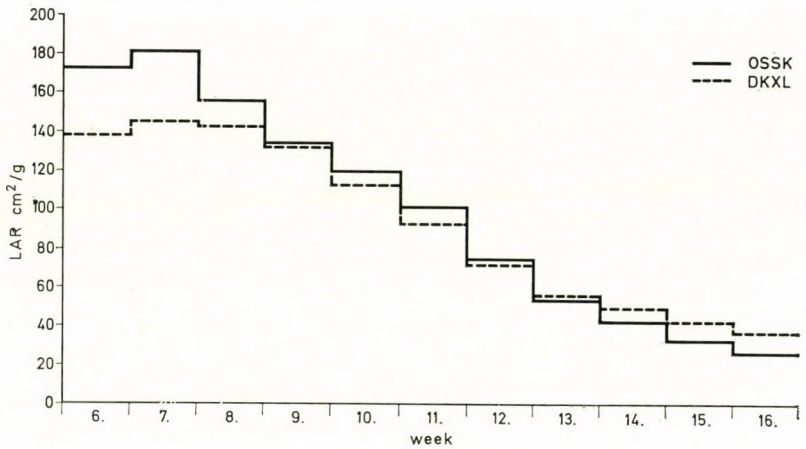


Fig. 8. Weekly LAR changes in the hybrids

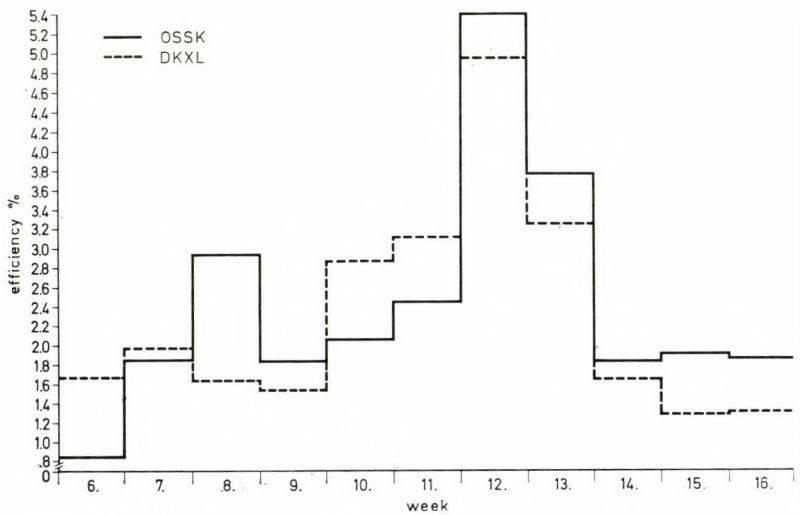


Fig. 9. Weekly efficiency percentage changes in the hybrids

Correlation analysis

Let us now examine the relationships between climatic factors (weekly mean temperature, weekly amount of precipitation, and weekly amount of solar radiation) and growth characteristics as well as the interrelationships of growth characteristics. Correlations were calculated by arranging the growth characteristics with the climatic data of the preceding week. In this way the total number of pairs makes 10. The correlation coefficients are given in Table 10. As is seen, the hybrids show an approximately identical correlation

Table 10

Correlations between the climatic factors and growth characteristics and between the growth characteristics themselves

	1	2	3	4	5	6	7	8	9	
1	=	−0.72	0.66	−0.53	0.16	−0.56	−0.59	0.47	0.07	OSSK-218
2	=	=	−0.91	0.32	0.15	0.18	0.30	−0.10	−0.06	
3	=	=	=	−0.19	−0.13	−0.06	−0.16	0.00	0.14	
4	−0.41	0.27	−0.27	=	0.20	0.72	0.95	−0.59	0.52	
5	0.10	0.12	−0.20	0.59	=	−0.01	−0.09	0.62	0.82	
6	−0.64	0.27	−0.12	0.58	−0.26	=	0.89	−0.91	−0.10	
7	−0.53	0.27	−0.23	0.94	0.32	0.81	=	−0.78	0.28	
8	0.51	−0.08	0.01	−0.42	0.48	−0.91	−0.65	=	0.26	
9	0.09	−0.08	0.04	0.67	0.90	−0.04	0.47	0.25	=	

DKXL-342

1 = weekly average temperature (°C)
2 = weekly amount of precipitation (mm)
3 = weekly amount solar radiation (h)
4 = RGR; 5 = NAR; 6 = LAR; 7 = RLGR; 8 = CGR; 9 = efficiency, %

r = 0.63—0.75, significant on 5% level
r = 0.76—0.86, significant on 1% level
r = 0.87—0.99, significant on 0.1% level

with the climatic factors. There is only one significant correlation between the climatic factors and the growth characteristics. Most significant correlations with another growth characteristic were manifested by the RLGR in both hybrids.

In the knowledge of the correlation coefficient, path analysis was carried out, in order to detect, and to estimate the causes of variabilities. The path diagram was prepared so as to allow the estimation of the influence of the climatic factors mentioned above on the growth characteristics examined, and also of the effect of growth characteristics on the RGR variability (Fig. 10); the enumeration in the figure is in agreement with that used in Table 10, the arrows indicating correlation — double-headed arrows — are used only between the climatic factors, and they are not represented between the growth characteristics; the error paths belonging to the various growth characteristics are not marked, with the exception of RGR; one-headed arrows indicate direct paths. The case of the correlated causes was chosen. First the effect of climatic factors on the variability of growth characteristics is discussed. Table 11 contains the estimation of the effect of climatic factors on the variability of growth characteristics in the hybrids. Each of the climatic factors has a positive effect

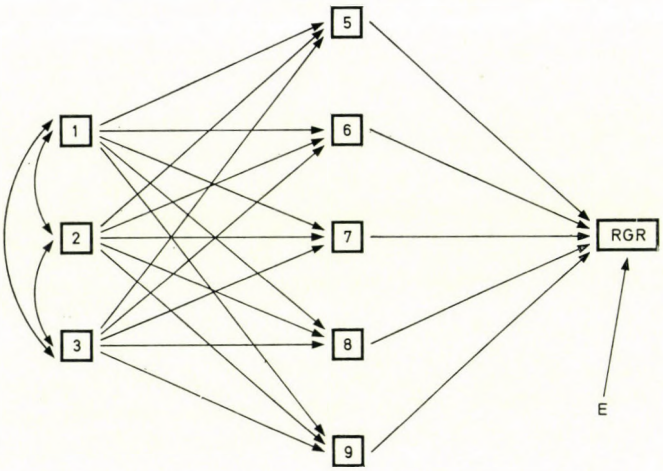


Fig. 10. The path diagram plotted by the authors (see text)

on the OSSK variability of NAR and efficiency. As for the RGR variability in DKXL, each of the climatic factors has a negative effect on them. It is remarkable that the other factors exert a relatively great influence in all cases.

Table 11

Paths between the climatic factors and the growth characteristics

	RGR	NAR	LAR	RLGR	CGR	Efficiency	
1.	−0.628	0.556	−0.899	−0.783	0.832	0.051	OSSK-218
2.	0.419	0.571	0.104	0.354	0.006	0.427	
3.	0.606	0.022	0.629	0.676	−0.541	0.495	
E	0.805	0.823	0.718	0.734	0.781	0.976	
							DKXL-342
1.	−0.446	0.392	−0.933	−0.698	0.943	0.069	
2.	−0.168	−0.088	0.287	−0.132	0.243	−0.205	
3.	−0.128	−0.539	0.757	0.111	−0.392	−0.193	
E	0.909	0.831	0.645	0.831	0.778	0.992	

1. = weekly average temperature
2. = weekly precipitation
3. = amount of weekly hours of solar radiation
E = error = other factors

The other growth characteristics exert different effects on the RGR variability of the two hybrids (Table 13). While RLGR exerts the greatest influ-

Table 12

Percentage distribution of the paths given in Table 11

	RGR	NAR	LAR	RLGR	CGR	Efficiency	
1.	39.46	30.94	80.98	61.36	69.19	0.26	OSSK-218
2.	17.58	32.58	1.09	12.54	0.00	18.26	
3.	36.73	0.05	39.55	45.72	29.26	24.54	
Direct effects	93.77	63.57	121.62	119.62	98.45	43.06	
Indirect effects	—58.58	—46.40	— 73.13	— 73.56	— 59.53	—38.33	
Other effects	64.18	68.61	51.51	53.94	61.08	95.27	
1.	19.92	15.40	87.01	48.71	88.98	0.48	DKXL-342
2.	2.83	0.78	8.27	1.73	5.89	4.23	
3.	1.65	29.07	57.35	1.23	15.33	3.71	
Direct effects	24.40	45.25	152.63	51.67	110.20	8.42	
Indirect effects	— 7.18	—14.30	— 94.26	— 20.79	— 70.74	— 6.92	
Other effects	82.78	69.05	41.63	69.12	60.54	98.50	

Table 13

The effect of NAR, LAR, RLGR, CGR and efficiency on the RGR variability

	OSSK-218		DKXL-342	
	path	%	path	%
NAR	—0.082	0.67	0.929	86.43
LAR	0.124	1.54	—0.057	0.33
RLGR	0.920	84.73	0.339	11.48
CGR	0.215	4.63	—0.657	43.19
Efficiency	0.284	8.05	—0.164	2.69
Direct effects		99.62		144.12
Indirect effects		— 2.82		— 44.11
Other effects	0.179	3.20	—0.0001	— 0.01

ence on the variability of RGR in OSSK, the greatest positive effect is exerted by NAR in DKXL. The influence of the other characteristics is not significant in any of the hybrids, which is contrary to the case of the climatic factors.

ACKNOWLEDGEMENTS

We express our thanks for the possibility of the investigations to Miklós ERDÉLYI, acting manager (Agricultural Combine, Bábolna), and to Béla MÉSZÁROS, chief agronomist of the "Kinizsi" Producers' Co-operative at Bana, as well as to the co-workers who participated in the measurements and calculations (from Vácrátót and Mosonmagyaróvár).

REFERENCES

BLACKMAN, G. E. (1968): The application of the concepts of growth analysis to the assessment of productivity. In: Functioning of terrestrial ecosystems at the primary production level. UNESCO, Paris, pp. 243—259.

BLACKMAN, V. H. (1919): The compound interest law and plant growth. Ann. Bot. **33,** 353—360. Cit. in: KVĚT—ONDOK—NEČAS—JARVIS, 1971.

BRIGGS, G. E.—KIDD, F.—WEST, C. (1920): A quantitative analysis of plant growth. I—II, Ann. Appl. Biol. **7,** 103—123, 202—223.

BRODY, S. (1945): Bioenergetics and Growth. Reinhold, New York.

DURAND, R. (1974): Estimation du rayonnement global à partir de la durée d'insolation. Ann. Agron. **25,** 779—795.

EVANS, G. C. (1972): Quantitative Analysis of Plant Growth. Blackwell, Oxford.

FISHER, R. A. (1921): Some remarks on the methods formulated in a recent article on the quantitative analysis of plant growth. Ann. Appl. Biol. **7,** 367—372. Cit. in: KVĚT—ONDOK—NEČAS—JARVIS, 1971.

GIOVANNARDI, R. (1972): Stima dell'area fogliare mediante misure biometriche ed applicazioni allo studio della dinamica di accrescimento del mais. Rivista di Agron. **6,** 243—248.

KEMP, C. D. (1960): Methods of estimating the leaf area of grasses from linear measurements. Ann. Bot. **24,** 491—499.

KVĚT, J.—MARSHALL, J. K. (1971): Assessment of leaf area and other assimilating plant surfaces. In: Plant Photosynthetic Production. Manual of methods. Ed. by ŠESTÁK Z.—ČATSKÝ, J.—JARVIS, P. G. pp. 517—555. Junk, The Hague.

KVĚT, J.—ONDOK, J. P.—NEČAS, J.—JARVIS, P. G. (1971): Methods of growth analysis. Ibidem, pp. 343—391.

MITSUDERA, M.—SAKAI, H. (1975): Survey on climate of the Kawatabi area. In: Ecological Studies in Japanese Grasslands. JIBP Synthesis. Ed. by M. NUMATA. **13,** 84—87, Tokyo Univ. Press.

ODUM, E. P. (1971): Fundamentals of Ecology. 3rd ed., Saunders, Philadelphia.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1—2), pp. 201—208 (1976)

ÜBER EINIGE PFLANZEN DES WESTLICHEN TIENSCHAN. II.

Von

Sz. Priszter

BOTANISCHER GARTEN DER EÖTVÖS L. UNIVERSITÄT, BUDAPEST

(Eingegangen am 2. Januar, 1976)

The author makes us acquainted with the history of the discovery of *Eremurus*-hybrids; enumerates all the artificial and spontaneous hybrids known up to now. He gives a name to the crossing *Eremurus regelii* × *E. turkestanicus* found in the West-Tien-Shan (*Eremurus* × *ludmillae* Levitschev et Priszter). The author describes a new variety of *Alcea nudicaulis* (var. *marthae*) and gives informations about several lususes and forms — all can be found in the Natural Protection Area of Tshatkalski Shapovednik. Finally there are mentioned some adventivous plants occurring in the neighbourhood of Tashkent.

5. **Eremurus**-Hybriden

Heute sind in dem sich von der Krim bis zum Himalaja erstreckenden ausgedehnten Gebiet schon mehr als 80 Arten der über einen sehr charakteristischen, eigenartigen Habitus verfügenden *Eremurus*-Gattung bekannt. Die erste *Eremurus*-Art (noch unter dem Namen *Asphodelus altaicus*) kennen wir fast seit 200 Jahren, den grössten Teil der Arten hat man aber — vor allem aus Mittelasien — erst in den letzten Jahrzehnten beschrieben. Systematiker der letzten Zeit (z. B. Khokhrjakov 1965) erheben zwar die anfangs als Genera, später als Subgenera bzw. Sektionen betrachteten Namen (*Ammolirion*, *Henningia*, *Selonia* usw.) wieder auf den Rang eines Genus, jedoch wurde dies nicht allgemein angenommen. So gebrauchen wir im weiteren nur den Gattungsnamen *Eremurus*.

Wegen der auffallenden, exotischen Form und Grösse der *Eremurus*-Arten (viele von ihnen sind 50—80, andere 100—150 cm hoch, einige erreichen sogar die Höhe von 3 m), ferner ihres massenhaften Auftretens fällt ihnen in der xerothermen Gebirgs-, zuweilen Wüstenvegetation Mittel- und Südwestasiens eine bedeutende Rolle zu. Mehrere ihrer Arten hat man bereits vor etwa 100 Jahren wegen ihrer prachtvollen Blüten auch in die Gartenkultur einbezogen (ich habe z. B. im Garten sogar 250—400 Blüten tragende, 80—100 cm lange Infloreszenz von *E. himalaicus* und *E. robustus* gesehen) und zur Jahrhundertwende begann man sogar einzelne Arten zu veredeln.

* I.: Acta Bot. Acad. Sci. Hung. **21** (1975) p. 377—386.

Zuerst wurde bloss die spontane Kreuzung einiger, in den europäischen Gärten gedeihender Arten beobachtet, aber in kurzer Zeit hat man auch mit der bewussten Arbeit der künstlichen Kreuzung begonnen. Die bekannteren älteren Kreuzungen (vgl. FEDTSCHENKO 1909: 83, 154—160) sind:

E. × *isabellinus*
E. × *Warei*
E. × *Shelford* } (*E. olgae* × *stenophyllus* var. *bungei*)

E. robustus Superbus
E. × *Himrob* } (*E. himalaicus* × *robustus*)

E. × *Tubergenii* (*E. himalaicus* × *stenophyllus* var. *bungei*)
E. × *Michelianus* (*E. stenophyllus* var. *bungei* × *Warei*)
E. × *Mrs. Reuthe* (*E. spectabilis* var. *marginatus* × *Warei*)

Das Vorkommen der *Eremurus*-Hybriden in der Natur begann man erst später zu erforschen. O. FEDTSCHENKO hat im Jahre 1909 das Vorhandensein der natürlichen Hybride *E. olgae* × *stenophyllus* nur noch in einer vorsichtigen Abfassung verifiziert (FEDTSCHENKO 1909: 94), B. FEDTSCHENKO verweist 1935 noch ebenfalls nur auf die Gartenhybriden der vier dekorativen Arten (*E. olgae*, *robustus*, *spectabilis*, *stenophyllus*), obwohl er die Aufmerksamkeit eigens auf die in der Natur entstehbaren *Eremurus*-Hybriden lenkt. WENDELBO schreibt hingegen schon (1964: 26), dass ». . . natural hybrids may be quite common as several species often grow together«. In einem eigenen Abschnitt seiner Arbeit (p. 26—29) erörtert er ausführlich drei Hybriden aus Afghanistan:

E. kaufmannii × *stenophyllus* ssp. *aurantiacus*
E. olgae × *stenophyllus* ssp. *stenophyllus*
(*E. albocitrinus* Bak., *E.* × *Shelford*, *E.* × *isabellinus*, *E.* × *Warei*)
E. robustus × *stenophyllus* ssp. *aurantiacus*.

VVEDENSKY erwähnt in einer seiner letzten Arbeiten (1971) unter den aus Mittelasien aufgezählten 45 *Eremurus*-Arten schon in grosser Zahl Hybriden ohne binäre Nomenklatur, lediglich mit der Angabe der Eltern. Diese sind — in alphabetischer Reihenfolge der Arten — die folgenden:

1. *angustifolius* × *stenophyllus*
2. *brachystemon* × *comosus*
3. *fuscus* × *regelii*
4. *iae* × *regelii*
5. *iae* × *robustus*
6. *kaufmannii* × *robustus*
7. *olgae* × *stenophyllus*
8. *regelii* × *turkestanicus*
9. *robustus* × *stenophyllus*
10. *sogdianus* × *turkestanicus*.

Anlässlich unserer in den Jahren 1973 und 1975 vorgenommenen Forschungen in Usbekistan konnte ich mit den botanischen Mitarbeitern des Gebietes von Tschatkalski Sapowednik unter den stellenweise in Massen gedeihenden vier *Eremurus*-Arten (*E. regelii*, *robustus*, *sogdianus* und *turkestanicus*, Abb. 1—4) die natürliche Hybride des *Eremurus regelii* ×

1

2

3

4

Abb. 1. Eremurus sogdianus (Rgl.) Benth. et Hook. f., Blütenstand
Abb. 2. Eremurus robustus Rgl., auf den Hängen über dem Tal des Basch-Kysil-Sai
Abb. 3. Eremurus regelii Vved., Blütenstand
Abb. 4. Eremurus turkestanicus Rgl., im Tal des Iran-Sai

turkestanicus an mehreren Stellen beobachten. Diese Hybride hat zwischen den voneinander morphologisch abweichenden beiden *Eremurus*-Arten einen ziemlich intermediären Habitus. Der Blütenstand der Art *E. regelii* (Abb. 3) ist dicht, das Perigon rosa-weinrot, die Kapsel hat eine tief gefurchte Oberfläche. Der Blütenstand der Art *E. turkestanicus* ist hingegen ziemlich locker (Abb. 4), das Perigon gelblich-grün, die Oberfläche der Kapsel glatt.

Die Hybride *Eremurus regelii*×*turkestanicus* habe ich zuerst am Fuss des Ak-Tasch in einer Höhe um 1800 m gesehen, während die im Laboratorium der Forschungsstation tätigen Forscher I. G. LEWITSCHEW und L. S. KRASOWSKAJA einige Exemplare ihrer in etwa 2000 m-Höhe im Unteren Minara-Gebirge beobachtet und auch eingesammelt haben. Da diese Hybride noch keinen binären Namen hat, haben wir sie zu Ehren der Sammlerin *Eremurus*×*ludmillae* genannt.

Eremurus×**ludmillae** LEVITSCHEV et PRISZTER, nomen novum
(*E. regelii* VVED.×*E. turkestanicus* RGL.)

Color perigonii illo *E. regelii* pallidior, sed *E. turkestanico* atrior. Inflorescentia non tam densa, quam apud *E. regelii*. Capsula leviter (non dense) rugosa. Antherae illis *E. turkestanici* similes: longae et deorsum recurvatae. Holotypus: inter parentes, in declivibus saxosis meridionalibus montis Minara Inferior (montium Tien-Schan Occidentalis), territorii protectionis naturae Tschatkalski Sapovednik dicti, alt. 2000 m.s.m. Leg.: Igor LEVITSCHEV et Ludmilla S. KRASOVSKAJA, 30. 5. 1975. Herbarium Horti Botanici Universitatis Scientiarum Budapest (Hungaria).

6. Alcea nudicaulis (LINDL.) BOISS. var. marthae PRISZTER

Die von *Althaea* abgesonderte Gattung *Alcea** ist im Kaukasus und in Mittelasien ziemlich artenreich (ILJIN beschrieb z. B. 10 neue Arten im Jahre 1949). Von den Arten ist in Mittelasien *Alcea nudicaulis* (Lindl. sub *Althaea*)

* Da die neuere internationale Fachliteratur noch kaum davon Kenntnis genommen hat was seit 1969 in der ungarischen Literatur bereits publiziert worden ist, muß ich hier erwähnen, daß wenn wir die von den *Althaea* abgesonderte Gattung *Alcea* anerkennen (und dies wird immer mehr anerkannt), so ist der gültige Name der ursprünglich aus Ungarn beschriebenen Art »*Althaea pallida* W. et K. ex Willd.« (Sp. pl. 3. 1800) nicht *Alcea pallida* (W. et K. ex Willd. 1800 vel 1801) W. et K. 1800 vel 1801 (Descr. Icon. Pl. Rar. Hung. **1**.). Diese Pflanze hat nämlich ursprünglich J. J. WINTERL um 1780 in Ungarn entdeckt und in seinem »Catalogus« aus dem Jahre 1785 (in Manuskript) kann die Art schon unter dem Namen »*Alcea nova*« (PRISZTER 1972b: 147, 1973: 99) angetroffen werden. In dem in Druck erschienenen »Index« des Botanischen Gartens zu Pest — der zugleich das erste Florenwerk über den mittleren Teil Ungarns ist — bringt WINTERL eine kurze Beschreibung und ein gültiges Binom darüber (dieses ist fast der einzige gültige Pflanzenname von WINTERL, da die Namen seiner übrigen Entdeckungen wegen des Gebrauches des bloß »neues« bedeutenden Wortes »novum« ungültig sind; vgl. PRISZTER 1972a: 7). WINTERL hat außer der kurzen Diagnose (»floret secundo anno, mox peritura. Spontanea hungariae flore pallido, caulis solitarius simplex«) auch eine Kupferstichtafel (fig. 23. p. 153) der Pflanze publiziert. Der gültige frühere Name von *Alcea* »*pallida* (W. et K.) W. et K.« ist demnach: *Alcea biennis* WINTERL 1788 (Index Horti Bot. Univ. Hung. p. 3). (PRISZTER 1969: 211, 1972a: 15; cf. Soó Syn. **4** 1970: 587, **5** 1973: 689.)
Syn.: *Alcea pallida* W. et K. ex WILLD. 1800 vel 1801
Althaea pallida (W. et K. sub *Alcea*) W. et K. 1800 vel 1801; BESSER 1822 (sec. Fl. URSR **7** 1955: 286.)
Althaea biennis (WINTERL 1788 sub *Alcea*) BORB. 1900, non *Althaea biennis* (M. B. 1808 sub *Alcea*) O. KTZE. 1891 quod est *Lavatera biennis* M. B. 1808.

Boiss., mit ihren schönen, weissen Blüten ziemlich verbreitet und kann eventuell als Ahne der bloss aus Kulturen bekannten *Alcea rosea* betrachtet werden. Der *Alcea rosea* ähnlich verfügt auch *Alcea nudicaulis* über einen ziemlichen Formenreichtum. So hat ILJIN (1949) — ihre Behaarung sowie die Zerteilung der Blattspreite in Betracht gezogen — mehrere ihrer Formen unterschieden (f. *subglabra*, f. *pilosa*, f. *hirsutissima*; f. *obtusiloba*, f. *acutiloba* Iljin).

Im Westlichen Tien-Schan haben wir eine auffallende Blütenabweichung beobachtet. Die Kronblätter der typischen *Alcea nudicaulis* sind unten und oben so breit, dass sich ihr Rand zum Teile deckt und die Blüte demzufolge dem Anschein nach eine Trichterform bildet (Abb. 5). Einen ähnlichen

Abb. 5. Alcea nudicaulis (Lindl.) Boiss. var. *nudicaulis*, Blüte

Blütenaufbau zeigen noch *Alcea rosea* oder auch mehrere *Linum*-Arten. — Bei der selteneren neuen Varietät der Art *Alcea nudicaulis* sind die Kronblätter hingegen schmal, stehen weit voneinander und im Spalt zwischen den Kronblättern sind die Kelchblätter gut sichtbar (Abb. 6—7). Einen diesem ähnlichen Blütenaufbau können wir auch bei anderen *Malvaceae*-Arten (z. B. *Lavatera thuringiaca*, *Malva silvestris* oder auch bei der in Tadschikistan heimischen Art *Alcea baldshuanica* (Bornm.) Iljin vorfinden.

Das im Gebiet Tschatkalski Sapowednik an mehreren Stellen vorkommende (und gewiss auch anderswo vorfindbare) neue Taxon habe ich mit meiner Frau gemeinsam gefunden und als Varietät (nicht bloss als Form) nach ihr benannt, da diese Varietät vom Typ morphologisch in bedeutenderem Masse abweicht und dieser abweichende Blütenaufbau bei anderen Arten der Familie *Malvaceae* — wie gesehen — ein konstant auftretendes Merkmal ist.

Alcea nudicaulis (LINDL.) BOISS. var. **marthae** PRISZTER, var. nova

A typo petalis angustis (supra 20—26, infra 7 mm latis) bene differt. Calyx inter ungues petalorum eminens.

Habitat in territorio protectionis naturae Tschatkalski Sapovednik dicto (et verisimiliter in aliis locis) montium Tien-Schan Occidentalis. In valle Iran-Saj prope stationem meteorologicam (cca 1200 m. s. m.) die 4. 6. 1975 legerunt M. et Sz. PRISZTER. Ad honorem detectoris: uxoris mei nominata. Holotypus in herbario Horti Botanici Universitatis Scientiarum Budapest (Hungaria) conservatur.

Abb. 6. Alcea nudicaulis (Lindl.) Boiss. var. *marthae* Priszter, Blüte

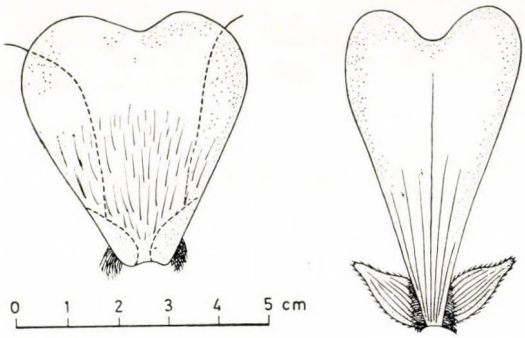


Abb. 7. Alcea nudicaulis var. *nudicaulis* (links) und var. *marthae* (rechts), Kronblatt und Kelchblätter

Die weissblütige Art *Alcea nudicaulis* haben wir im allgemeinen zwischen 1000—1500 m. ü. M., in der Waldsteppenzone gefunden. An den westlichen Ausläufern der Gebirge — so z. B. in der Umgebung von Parkent — haben wir auch rosafarbene Individuen gesehen (jedoch nur aus dem Autobus beobachtet). Es werden weitere Untersuchungen an Ort und Stelle nötig sein, um entscheiden zu können, ob die dortige Pflanze eine Hybride der Art *Alcea rosea* ist oder ob sie eventuell mit der aus Tadschikistan erwähnten *Alcea sangardensis* Iljin (nomen nudum, in Fl. URSS **15.** p. 110—111) mit rosafarbenen Blüten und tiefgespalteten Blättern identifiziert werden kann.

7. Einige Farbabweichungen aus dem Westlichen Tien-Schan

Calophaca tianschanica (B. Fedtsch.) Boriss. lus. **aurantiaca** Priszter, lus. novus
A typo floribus aurantiacis (non aureis) differt.
Cerasus erythrocarpa Nevski lus. **albiflora** Priszter, lus. novus
A typo floribus albis (non roseis vel purpureis) differt.
Onobrychis grandis Lipsky lus. **purpurea** Priszter, lus. novus
A typo floribus laete purpureis (non roseis vel alboroseis) differt.
Hypericum scabrum L. lus. **citrinum** Priszter, lus. novus
A typo floribus citrinis (non flavis) differt. Frequens.
Impatiens parviflora DC. f. **albiflora** Priszter, f. nova
A typo floribus albis (non ochroleucis) differt. Formae ab hoc divergentes sunt: f. *albescens* Rohlena 1926 (fauce aurantiaco) et f. *bicolor* Leeder in Neumann 1929 (fauce calcarique purpurascente). Forma nostra albiflora in regione Tien-Schan Occidentalis frequens esse videtur.
Helichrysum maracandicum M. Pop. et Kirp. lus. **albescens** Priszter, lus. novus
A typo squamis fere albis (non laete flavis) differt.
Korolkowia sewertzowii Rgl. lus. **viridiflora** Priszter, lus. novus
A typo floribus toto viridibus (non brunneo-purpureis vel viride-purpureis) differt.
Allium barszczewskii Lipsky lus. **albidum** Priszter, lus. novus
Color florum plantae typicae variabilis: laete purpureus, roseopurpureus, roseus; pedunculis purpureis. Lusus *albidum* a typo petalis fere albis pedunculisque albis (vel purpurascentibus) differt.
Allium iodanthum Vved. lus. **roseolum** Priszter, lus. novus
A typo floribus roseolis (non atropurpureis) differt.
Juniperus serawschanica Kom. f. **glauca** Priszter, f. nova
A typo foliis glaucoviridibus differt. Color haec apud diversas Coniferas frequenter proveniens.
Lusi formaeque haec omnes in territorio protectionis naturae Tschatkalski Sapovednik dicto provenientes. Holotypi omnes — anno 1975 lecti — in herbario Horti Botanici Universitatis Scientiarum Budapest (Hungaria) conservantur.
Isatis boissieriana Rchb.f. lus. **purpurea** Priszter, lus. novus
A typo siliculis purpurascentibus differt. Prope urbem Samarkand, die 2. 6. 1975 lecta. Holotypus (Nr. 8125/75) in herbario Horti Botanici Universitatis Budapestinensis conservatur.

8. Einige Adventivpflanzen aus Taschkent

Crambe amabilis Butk. et Majlun. Eine im Jahre 1962 aus Kasachstan beschriebene Art, die an Ruderalstellen auch in Usbekistan sich zu verbreiten scheint. — In ruderatis ad urbem Taschkent et in regione vicina (e. gr. prope Tschimgan). An apophyton?
Polygonum cuspidatum Sieb. et Zucc. = **Reynoutria japonica** Houtt. — In hortis culta et in urbe Taschkent pluribus locis subspontanea.
Duchesnea indica (Andr.) Focke. — Planta ornamentalis et in locis compluribus urbis Taschkent (e. gr. in hortis publicis privatisque) saepe subspontanea.
In Horto Botanico Academiae Scientiarum Usbekistanae (in urbe Taschkent) plantas sequentes adventivas vidi: *Fibigia macroptera* Boiss. (ex Caucaso et Asia Minore), *Anemone pennsylvanica* L. (ex America Boreali), *Duchesnea indica* (Andr.) Focke (ex Asia Australi et Orientali).

DANKSAGUNG

Der Verfasser spricht seinen aufrichtigsten Dank für die Hilfe den Kollegen des Botanischen Lehrstuhls der LENIN-Universität und des Herbars der Usbekischen Akademie der Wissenschaften zu Taschkent, sowie des Herbars der mittelasiatischen Sektion des KOMAROV-Institutes zu Leningrad aus.

LITERATUR

CZEREPANOV, S. K. (1973): Additamenta et corrigenda ad "Floram URSS" (tomi I—XXX). Leningrad. 668 pp.

FEDTSCHENKO, B. A. (1935): Eremurus; in Flora URSS. **4,** 37—52, 733—734.

FEDTSCHENKO, O. (1909): Eremurus, Kritische Übersicht der Gattung. Mém. Acad. Sci. St. Petersburg. **8,** Sv. 23. 210 pp.

KHOKHRJAKOV, A. P. (1965): Eremurusi i ich kultura. Moskwa.

ILJIN, M. M. (1949): Alcea; in Flora URSS. **15,** 108—111.

PRISZTER, Sz. (1969): Zur Geschichte des Botanischen Gartens der Universität zu Pest. 1. Die ersten Abbildungen und Beschreibungen ungarischer Pflanzen aus dem Jahre 1788. Bot. Közlem. **56,** 207—219.

PRISZTER, Sz. (1972a): The first floristic work from Central Hungary. Postscript to the facsimile edition of Winterl's Index compiled in 1788. Budapest, 26 pp., 4 tab.

PRISZTER, Sz. (1972b): Zur Geschichte . . . 5. Beginn der Florenforschung in Mittelungarn. Bot. Közlem. **59,** 145—154.

PRISZTER, Sz. (1973): Zur Geschichte . . . 6. Winterls handschriftlicher Pflanzenkatalog (1785). Annal. Univ. Sci. Budapest., Sect. Biol. **15,** 93—101.

SIKURA, I. I. (1971): Dekorativni Eremurusi ta ich kultura na Ukraini. Kiew. 96 pp.

VVEDENSKY, A. I. (1941): Eremurus; in Schreder (red.): Flora Uzbekistanica. Taschkent. **1,** 400—410.

VVEDENSKY, A. I. (1971): Eremurus; in Conspectus Florae Asiae Mediae. Taschkent. **2,** 14—27.

WENDELBO, P. (1964): On the genus Eremurus (Liliaceae) in South-West Asia. Acta Univ. Bergensis. Ser. Math. Rer. Nat. **5,** 1—45.

WINTERL, J. J. (1788): Index Horti Botanici Hungariae, quae Pestini est. Pest. (Faksimile: Budapest, 1972, 161 pp.)

ADDENDA AD PARTEM I. HUIUS OPERIS

(Acta Bot. Hung. **21.** 1975. p. 385.)

Loca natalia nova *Sedi ewersii* ex Herbario Univ. Hauniensis (København, Danmark):

Sedum ewersii LEDEB. var. *ewersii:*
Afghanistan: Minjan (leg. L. EDELBERG, 1948),
W. Pakistan: Naran (leg. G. HAMMER, 1969);

Sedum ewersii LEDEB. var. *homophyllum* PRAEG.:
Afghanistan, Nuristan: Pashki (leg. G. HAMMER, 1969); (varietas haec ad floram afghanicam nova; determ. Sz. PRISZTER, 1967).

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1—2), pp. 209—247 (1976)

THE CARPOLOGICAL EXAMINATION OF WILD-GROWING VINE SPECIES OF HUNGARY, I

By

A. TERPÓ

DEPARTMENT OF BOTANY AND BOTANICAL GARDENS OF THE UNIVERSITY OF HORTICULTURE

(Received March 12, 1976)

The author carries out his botanical examinations of wild vine stands in the Carpathian Basin, *i.e.* in the area of Hungary, rich in characteristic autochthon species. Since the end of the 19th century, no thorough studies on the stand have yet been published. It is noteworthy that the northern boundaries of Hungary more or less coincide with the northern boundaries of both the distribution of *Vitis sylvestris* Gmel. (grove vine) and the growth of *V. vinifera* L.

In the area mentioned above, *V. riparia* Michx. besides *V. sylvestris*, increasingly gains ground too. It is for the first time that, after the cenological characterization of the habitats of both species, the diagnostic character and data of cluster-, berry-, and seed, among them berry size and berry weight correlation data, of *V. sylvestris* obtained from nine habitats are described on the basis of a botanical analysis.

The seed plays a primary part also in the classification of the basic species of vine. The author considers as basic species those wild vines which use to grow for the selection of stock cultivars or fruiting cultivars (grapevine, table grape).

The most important dimensions of *V. sylvestris* seeds, compared to those of the Austrian and Upper-Rheinish vine-seeds, are given in tables, with reference to habitats. The *V. riparia* seeds are presented in a similar manner. The author groups the wild vine seeds by the length data of the seeds.

Investigations into the two species reveal that during seed length growth the seed beak grows quicker as compared to seed corpus.

Several comparisons have been made with the diagnostic characters of *V. vinifera* seeds. By means of calculating several ratios — diameter/length (occasionally its reciprocal that is length/diameter), beak length/seed length — the author characterizes the seed of the two wild-growing vine species in Hungary. While making the comparisons with *V. vinifera*, the author calls attention to similarities (for example, seed diameter) and to dissimilarities as well; as for example the problem of short beak and wide chalaza.

Introduction

The rich flora of the Carpathian Basin, the occurrence of the characteristic Pannonian-Balkanian and Pontian plant species had already early aroused the attention both of Hungarian, and especially West-European botanists. Many eminent botanists like PÁL KITAIBEL, VINCE BORBÁS, ÁRPÁD DEGEN, ÁRPÁD KISS, LAJOS SIMONKAI, VIKTOR JANKA, SÁNDOR JÁVORKA, ZOLTÁN KÁRPÁTI, JENŐ KELLER, IMRE MÁTHÉ, GUSZTÁV MOESZ, GYULA NYÁRÁDI, ANTAL PÉNZES, RAYMUND RAPAICS, JÁNOS WAGNER, ENDRE GOMBOCZ, JENŐ BERNÁTSKY, REZSŐ SOÓ, BÁLINT ZÓLYOMI explored the Hungarian flora, and achieved noteworthy results even at international level. Notwithstanding all this, the *Vitis* stands with regard to taxonomy have remained almost untouched.

The Hungarian-born Professor E. RÁTHAY of Klosterneuburg (Austria) was almost the first (1889 Vol. V.) after KERNER (1857) to pay attention to the vine populations alongside the Danube (1888/1889; 1892/1893). His vine carpological examinations, the detailed analysis of the sexual dimorphism of *V. sylvestris* serve as a basis even today for every research into *V. sylvestris* and *V. vinifera*. Today in Hungary P. KOZMA (1963, 1964, 1966 etc.) is an outstanding contributor to the carpological research of cultivated vines at an up-to-date level.

HEGEDÜS (1966, 1968, 1969) published the results of his vine anatomical and morphological research in several papers and books.

ANDRASOVSZKY (in JÁVORKA, 1924—1925), also a Hungarian, who achieved fame with his systematization of cultivated vines, did not deal with vine stands growing wild. ANDRASOVSZKY's view (l.c.) on wild-growing vines is well-reflected by his following words: "The *V. silvestris* Gmel. . . . contains the forms of several *V. vinifera* group cultivars occurring especially in the south; their flowers, owing to the discontinuation in cultivation, are often but not always unisexual". ADNRASOVSZKY's contemporary, GÁYER (1928), who was a great advocate of ANDRASOVSZKY's system of cultivated vine, considered *V. sylvestris* as an autochthony of vines growing alongside the watercourses.

ANDRASOVSZKY (1915—1917) was the first in Hungary to systematize the vine species by the shape characteristics of the seeds. Today it is FACSAR (1967; 1970; 1971) in our Institute who deals with the question and who compiled the so-called seed type group system of *V. vinifera* cultivars (1972).

Among the specialists of the practical field I'só (1954) was the first to take notice of the mass occurrence of *V. riparia* alongside the river Tisza. Botanists did not indicate the presence of this species; it is considered even today as *V. sylvestris* (for example, MAGYAR, 1960). In our opinion, a thoroughgoing botanical elaboration was much hindered by the view—which can be considered as general — that the wild-growing vine stands of Europe essentially consist of escaped plants, thus it is not worth-while to deal with them. This attitude seems to be confirmed by 'accepted' handbooks, too. For example REHDER (1951) says: "The spontaneous or subspontaneous form is sometimes distinguished as (*V. vinifera* L.) var. *sylvestris* Willd. . . ."

These had been the preceding phases of research when we started to make a project and became engaged in solving this problem (TERPÓ, 1962; 1963; 1969; 1974). Our research could essentially be based besides the results of RÁTHAY, on those of the French LEVADOUX, the Roumanian POP, the Yugoslavian TURKOVIĆ and Soviet NEGRUL'. The good personal relationships that developed between the latter two and us had to a great extent favourably influenced the organization and accomplishment of *V. sylvestris* research, the final target of which was to elaborate the origin, taxonomical classification

and ecological conditions of *V. sylvestris*, and the problem of its being related to *V. vinifera* and *V. riparia*.

In the present paper we describe and discuss only the characteristics and correlative connections of the fruit and seed.

Material and method

Research into wild vine partly consists of field study. By doing this we carry out the cenological elaboration and the collection of soil samples to obtain ecological data; the investigations into sex distribution; the estimation of the conditions of the plants (disease, etc.); the surveying of phenological data; and the collection of fruits.

Since 1964, continually, we have established a living collection from the materials gathered — in the "Botanical Gardens of Soroksár" belonging to the Department of Botany of the University — mostly by sowing the seed. The soil of the area (slightly humic sand of chernozem character) developed on sand dunes characteristic for the Danube–Tisza Mid-region. Its annual moisture quantity is 552 mm, annual mean temperature 10.2°C, the first autumn frost generally appears on the 11th of October.

The fruits of the cultivated and of the wild-grown materials were measured and evaluated according to practice in ampelography; the shape of the berry was depicted by drawing. The berries were grouped according to the number of seeds they contains; their shape data were obtained by means of a stereomicroscope, on the basis of the pattern shown in Figs 8—9; the magnification of the ocular micrometer was 12.5×, that of the objective was 1×. We endeavoured to obtain data useful both in taxonomical and archaeological research.

In the evaluation of the data recorded I applied various mathematical-statistical methods. In order to determine the rate of variability of the characteristics, of their distribution and variation, I calculated the variances and the significance $\left(s = \sqrt{\frac{SQ}{n-1}} = \sqrt{s^2}\right)$. I compared the variation of the different characteristics of the fruit and the seed — the deviation related to the average, in percentage — by means of the variation coefficient as

$$\left(s\% = CV = \frac{s \cdot 100}{\bar{X}}\right).$$

The values of the variation coefficients were estimated as the following variation classes:

1. 0—10% — the characteristics are invariable and as such are usable also for distinguishing infraspecific taxa;
2. 10—20% — the characteristics show a moderate variation, and can be used satisfactorily in distinguishing species;
3. 20—30% — the coefficient represents a high degree of variation which can be traced back to species rich in infraspecific taxa, to hybrid populations, and often to the effect of extreme ecological conditions;
4. 30% — the coefficient represents an extreme fluctuation in the characteristics.

When examining the correlations between seed number and berry volume, I also calculated the values of confidence interval.

Among the ratio numbers, mainly the seed index values (length/diameter or its reciprocal diameter/length), used also in ampelogical researches, were calculated and the results were plotted graphically. This mode of representation was considered important especially since through it a possibility was offered to me to compare my data with those of other authors.

The length and diameter of the seed were measured and used in all cases, similarly to the length of the beak. Certain morphological characteristics (such as the length and diameter of the rosette) were measured only for informatory purposes.

Besides the above data, the qualitative diagnostic characters of the seeds were also determined: the shape of the seed, the form of the base and beak, the sculpture of the dorsal and the ventral sides, the colour and the glaziness of the seed.

A minimum of 20 seeds of one type was used in the calculations; in cases of easy access 100 seeds per plant were collected.

The correlations between seed numbers and berry sizes per berry were examined by means of a regression analysis; the results are given as correlation coefficients, data pairs, regression coefficients with their significance and the regression equation.

The mathematical-statistical calculations that have been applied are principally based on the work of SVÁB (1967).

Results

In our research we examined also the origin of the wild vine populations since in the case of every plant which has also a category of cultivated form, the suspicion of the plant having been escaped from domestication inevitably arises. Another view is that which simply considers all wild vine plants as the remnants of old civilizations, that is "escapes". I have already used the method of investigating the origin of other plants, too (TERPÓ 1960); the fruitfulness of this method has emerged especially in the case of wildgrowing *Pyrus* stands.

Wild vine stands can be classified into the following groups:

(1) *Autochthon stands or species*, the origin of which can be proved irrespective of any doubt (by means of cenological, palaeontological and archaeological, etc. methods). Similarly, as every plant, anyhow these original basic species can be drawn into cultivation (for example as stock cultivars, or ornamental plants) as well, when, however, they maintain their original characteristics. Such vine plant is *Vitis sylvestris* in the examined area.

(2) *Subspontaneous vines*, which are adventitious elements for the natural flora (Figs 1 and 2). They can behave in an ephemeral way or as naturalized plants and can become permament members of the natural flora in Europe as well; such are for example *V. riparia*. These plants under such ecological conditions that is they are similar to their original habitat, are (a) competitive; (b) resistant to various diseases and insect damages to localities at least to as high an extent as in their original lands; (c) their variability also attains the degree detectable in their old habitat: (d) they spontaneously hybridize with the related species to be found here. All these allow us in Hungary to infer in the case of *V. riparia* that the secondary centre of origin of the species has developed here (of which hybridization is, of course, not a criterion).

2.1. *Subspontaneous basic vine species* (see the foregoing paragraph).

2.2. *Subspontaneous variety* (cultivars). In the course of our researches we have found a few plants of direct producer of variety in subspontaneous state in Hungary. The subspontaneously growing roots of the variety traditionally cultivated here (for example, 'Hárslevelű', 'Furmint' and 'Kövidinka') have not been found in the original vegetations. For the time being only one plant of *V. vinifera*-like vine has come into light in the subspontaneous state from the outskirts of the village Csesznek in the Bakony Mountains.

(3) *Culture relicts*. In discontinued plantations, viticultures often continue to grow where they had been cultivated even at the time when as a

Fig. 1. Feral *Vitis riparia* Michx. in the edge of the reed bank; Békésszentandrás 1962 (photo: A. TERPÓ)

Fig. 2. Feral, direct producing vine cultivar of *V. labrusca* origin; Iregszemcse 1965 (photo: A. TERPÓ)

result of succession the area is gradually reclaimed by the original flora. Owing to various causes (wars, phylloxera), mainly in the Hungarian Central Range of Mountains, the plantations of the mountain sides often were abandoned. Unfortunately, in these areas, where in several cases natural forest stands have already developed (for example, Tállya in the Zemplén Mountains), no vine plants of several centuries old have been found. In the areas the flora of which originates from only the last 30—100 years (after the phylloxera plague), *V. vinifera* cultivars were found in a very run-down state, and some relatively more vigorous direct producers (for example, the cultivar 'Jacquez', which is of *V. aestivalis* origin) in the abandoned vine-yards of the Pilis Mountains.

Nor did we find the continuation of reproduction of the cultivars in these areas. On the other hand, the under-stock vines manifest great vitality in the abandoned vine plantations, first of all the *V. riparia* derivatives, but the plants of *V. berlandieri* and *V. rupestris* origin live also for a rather long time (Plate II).

The method of LEVADOUX (1956) was to classify wild vine stands also according to their origin. LEVADOUX's point of departure is the supposition that the origin of feral vine plants can be traced back to one-time cultivated but later abandoned vine plantations where they reached a wild-growing state.

We cannot start from this standpoint, *i.e.* beginning the "system" of wild-growing vine stands with cultivated vines, since at the very beginning the thought would arise that we want to deduce autochthon species from cultivated varieties.

We can prove without doubt that *V. sylvestris* has been autochthon (JÁRAI-KOMLÓDI, 1966; 1968; 1969) in the area of Hungary, in the Carpathian Basin, since the post-glacial warm periods (7500 B.C.); wild vine stands are primary to the cultivated vine stands of various origin. The European wild vine which had lived in this area as early as the Atlantic phase (Holocene 5th zone) can without hiatus be fit into the category of *V. sylvestris* form which exists today. (On this question we shall report in detail at a later date).

If we want to group the wild-growing fruit-plants according to their "origin", automatically the question arises whether only the state of going feral is possible; we think that domestication also exist and did exist, and we must emphasize that the cultivated vines of today have come into existence in this way. The process of domestication cannot be left out of consideration. To this, significant examples are to be found in *Pyrus* species, in Bulgaria and Yugoslavia, where several wild *Pyrus* species are autochthon. The very primitive cultivars are still "pure" species derivates and are not the elements of the so-called multi-hybrid garden pears. These forms are not the products of going feral, but are on the boundaries between wild and cultivated state.

Similarly as in the case of other fruit-growing plants, we shall have to suppose that the cultivated *V. vinifera* segregated from a *V. vinifera* population which, although it was growing wild, had already been bisexual. Bisexuality also meant a guarantee for a higher production rate and promoted a better fertility rate and, indirectly, the formation of larger berries. (We cannot now go into details of this topic.)

Habitat data. For the presentation of earlier *Vitis* habitat data the most appropriate thing to do is to quote the Austrian KERNER (1875), who paid attention to the occurrence of vine both in the Hungarian Central Range of Mountains (Pilis Mountains), and the areas of the Hungarian Plain: "nirgends aber schöner und in grösserer Menge als zwischen Visegrád und Szt. László, wo auf einer Strecke von mehreren Jochen im Buchenwalde fast jeder Baumstrunk des Hochwaldes von Weinreben umrankt und die Baumkronen mit den üppigsten Rebengewinden übersponnen sind. Massenhaft in den Auen im Stromgelände der Donau bei (Párkány) Nána und auf der Margaretheninsel bei Ofen (Budapest), wo die Reben uralter Weinstöcke bis zu den höchsten Wipfeln der Pappeln und Eichen emporklettern. In der Stuhlweissenburger Niederung im Walde bei Vajta und auf der Kecskemeter Landhöhe in den Wäldern bei Monor und Pilis und auf Puszta Peszér bei Alsó Dabas." Thus, wild vine — presumably and mostly *V. sylvestris* — had a mass occurrence in Hungary. Today we can see only the traces of the one-time frequency of *V. sylvestris*, the last decaying roots, which are partly replaced by the spreading *V. riparia*, alongside with our large rivers (Fig. 3).

In the light of cenological literary data (Soó, 1966), *V. sylvestris* is a *Salicion albae* and *Alno-Padion* species (*Fraxino pannonicae-Ulmetum*, *Salicetum albae-fragilis*) of narrow forests along watercourses. Our researches into origins were launched on the basis of data partly from former flora works and literary reports (BORBÁS, 1879; BOROS, 1925; GÁYER, 1925; 1928; I'só, 1954, JÁVORKA, 1924—1925; KERNER, 1873; 1875; MAGYAR, 1960; MÁTHÉ, 1936; NEILREICH, 1866; RÁTHAY, 1888; 1889; 1893; ZÓLYOMI, 1958) and partly from personal communication with botanists, and specialists of horti- and sylviculture (*e.g.* Z. KÁRPÁTI, I. KÁRPÁTI, M. ÚJVÁROSI, I. MÁTHÉ, J. PAPP and G. VIDA). Our results are as follows.

(a) At a few points of the Hungarian Central Range of Mountains, *Vitis sylvestris* still occurs in a very small number; namely, (i) in the Naszály Mountain below the Börzsöny Mountains, (ii) in the Northern Bakony Mountains, (iii) at Diósgyőr on the eastern flank of the Bükk Mountains, and (iv) in the Zemplén Mountains. (We have only a herbarium sheet of the plant obtained from the Bükk Mountains, the plant of the Zemplén Mountains has been cut out.)

Another of the most precious habitats lies in the Southern-Transdanubian part of Hungary, where — in the "Zselicség" and on the southern

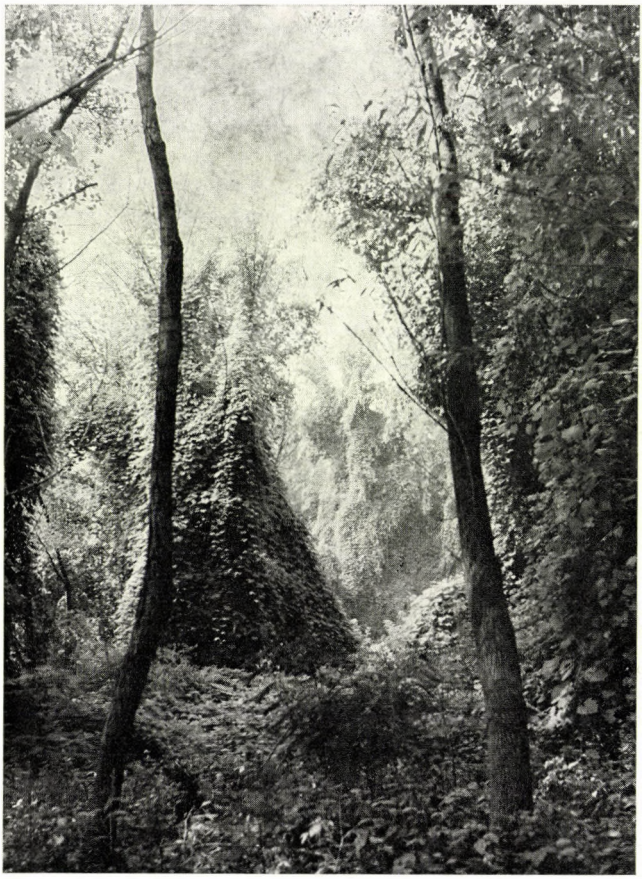


Fig. 3. Vitis riparia Michx. in the willow-poplar groves of "Tőserdő" alongside the river Tisza; Lakitelek 1975 (photo: GY. TERPÓ)

slope of the Mecsek Mountains — some extensive stands of *Vitis sylvestris* occur here and there.

Grove vine grows in habitats Nos (i) and (ii) in the beech forest zone. It is characteristic of the association [*Melico-Fagetum*(*Melitti-Fagetum* Soó 62)] that it consists of trees not of the same age. The vines creep up to enormous beech trees that have lived up to at least two cutting turns (about 200 years old). *Acer pseudo-platanus*, *Cerasus* (*Prunus*) *avium* and *Fraxinus excelsior* also are to be found in the tree stratum in addition to the beech trees. *Hedera helix*, *Carex pilosa*, *Vinca minor*, *Viola silvestris*, *Asperula odorata* and *Lamium geleobdolon* appear in the herb stratum (frequently as facies) with a rather large coverage (A—D: 1—3). In the Bakony Mountains, even *Arum alpinum* occurs frequently. In the Börzsöny Mountains, *Carpinus betulus* and in the Bakony Mountains *Quercus cerris* and *Acer campestre* push inward the stands of the beeches.

Plate I. Vitis sylvestris Gmel. from the forests south of Kaposvár, in the Transdanubian Hills drawn by Mrs. F. LEXA

In habitat No. (i), in associations of talus slopes with linden woods (*Mercuriali-Tilietum* ZÓLYOMI et JAKUCS 58), *V. sylvestris* grows in the almost impenetrable shrubbery of *Clematis vitalba* and *Staphylea pinnata*, and it even creeps up to the crowns of *Fagus silvatica* and *Tilia platyphyllos* (TERPÓ, 1969).

(b) The *V. sylvestris* habitats of hilly countries and flat-lands in Hungary are also worthy of note. Grove vine occurs in greatest number in the *Tilio argenteae-Quercetum petraeae-cerris* Soó 57 association in Hungary, in the habitats of Southern-Transdanubian, Zselicség, south of Kaposvár. Besides the characteristic sub-Mediterranean-Illyrean species of the associa-

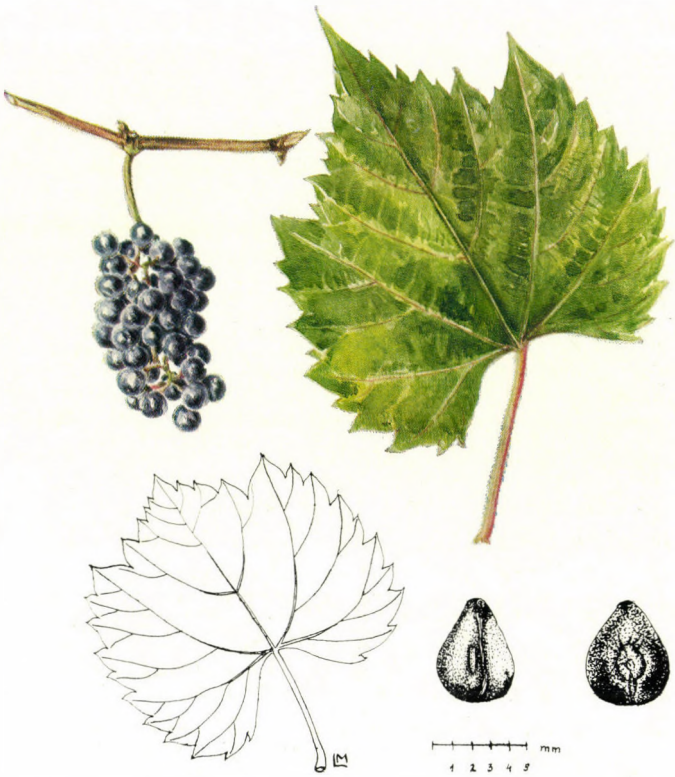


Plate II. Vitis riparia Michx. from the Island of Háros alongside the Danube near Budapest (drawn by Mrs. LEXA)

tions which have developed on loess soil (*Tilia argentea*, *Rosa arvensis*, *Helleborus odorus*, *Tamus communis*, etc.) *Fagus silvatica* also occurs sporadically. It was only here that the revival of *V. sylvestris* from seeds could be experienced.

Grove vine has disappeared from the overwhelming majority of our flat-land areas. A few specimens of it grow on the edges of small forest spots in the habitat remnant embraced by the towns of Pécs and Szigetvár and by the river Dráva. These hornbeam grove associations of the Hungarian Plain (*Querco robori-Carpinetum* Soó et Pócs (31) 57b) represent a transition to the oak-ash-elm groves which are close to them both ecologically and floristically; the rather frequently-occurring *Acer tataricum* is remarkable, while in the herb layer *Arum alpinum* is replaced by *Arum maculatum*.

It is characteristic of the entire European area of distribution of *V. sylvestris* that it follows river courses. As it has been mentioned in the introduction, *V. sylvestris* occurred in masses in the whole of its European area. Today it is rare everywhere.

Fig. 4. Old *Vitis sylvestris* Gmel. (grove vine) in an island along the Danube; Alsógöd 1970 (photo: A. TERPÓ)

Vitis sylvestris is to be found in a very small number (sometimes only a plant here and there, as for example on the banks of the Danube near Szentendre) in a few stands of the oak-ash-elm groves (*Fraxino pannonicae-Ulmetum* Soó 60). It is characteristic of the association that on higher altitude *Quercus robur* (A—D: 1—3), *Acer campestre* (1—2), *Ulmus foliacea* (1—3), *U. laevis* (1), *Acer tataricum* (1), *Corylus avellana* (1—2) and *Ligustrum vulgare* (1—2), while on herb stratum *Iris variegata*, *Arum maculatum*, *A. alpinum*, *Galanthus nivalis*, *Convallaria majalis*, *Scilla bifolia*, *Polygonatum latifolium*, and *P. multiflorum* are frequent (Fig. 4).

On river terraces the slope of which are shelter-like, *V. sylvestris* associations join together, mix with the *Salicetum-albae-fragilis* Issler 26 em. Soó 57 species which is usually characteristic of the next, lower terraces. In these cases, *Populus alba* (A—D: 2—3) and *Fraxinus pannonica* (1) appear with greater coverage, but in certain areas the feral species appear in great masses.

Thus, *Acer negundo*, *Morus alba*, *Celtis occidentalis*, *Amorpha fruticosa* and *Parthenocissus quinquefolia* can be referred to as generally wide-spread in these areas.

The true habitat of *Vitis riparia* is found mostly in this willow-grove. The extensive establishments of this so-called riverside vine usually develop into impenetrable "jungle", often overlapping into the shrub-willows (*Salicetum triandrae* Malcuit 29 and *Salicetum purpureae* Wendelberger—Zelinka 52; the latter by the Danube bank) and into the hardwood groves lying on the higher terraces (*Fraxino pannonicae-Ulmetum*), especially along the stream Bodrog and the Danube. The hybrids of the two vine species are found also in the transitory zone. *Vitis riparia* by creeping up the trees, gradually intertwines the *Salix* and *Populus* species, and also the crown of *Ulmus laevis*, producing thereby huge green curtains which are tent- and labirinth-like at the same time. The mass of lianes of a great weight, sooner or later "strangles", the trees, due to covering their foliage; the weakened or destroyed trees interwoven by masses of lianes fall onto the ground giving the area the appearance of a tropical undisturbed jungle.

The fruit of vine

Fruit-growing plants are usually first examined as far as the distinguishing character of the fruit, the development of the characters, the correlation between useful and less valuable diagnostic characters are concerned. The fruit characteristics of wild-growing basic species (parent species) are essential from the viewpoint of survival and spread of the plant but — since in the investigations into cultivated plants the basic species may represent the "real control" — the results obtained in this way are also worthy to be used in cultivated plant researches (by improving them).

Maturing time. According to GMELIN (1805), *V. sylvestris* is of late ripening: "Baccas maturat Novembri". Our own observations generally confirm him. In the habitat areas of both the Bakony Mountains and the Zselicség (south of Kaposvár) certain specimens occur whose fruit ripen only in 10%. And when the December freeze ensues, the clusters remain on the leafless lianes, often until spring-time. Owing to the variability of the populations certain specimens of the vine establishments ripen already as early as the end of September (Fig. 5).

The fruits of *V. riparia* ripen earlier: from the end of August. A larger proportion of maturing time falls in September. It is a remarkable phenomenon that the *riparia* × *sylvestris* hybrids are mostly early maturing (second half of August) and that they are much favoured by birds.

The clusters of the wild vine species mentioned above are generally loose (Figs 5 and 6); this refers especially to *V. sylvestris*. Dense squat clusters

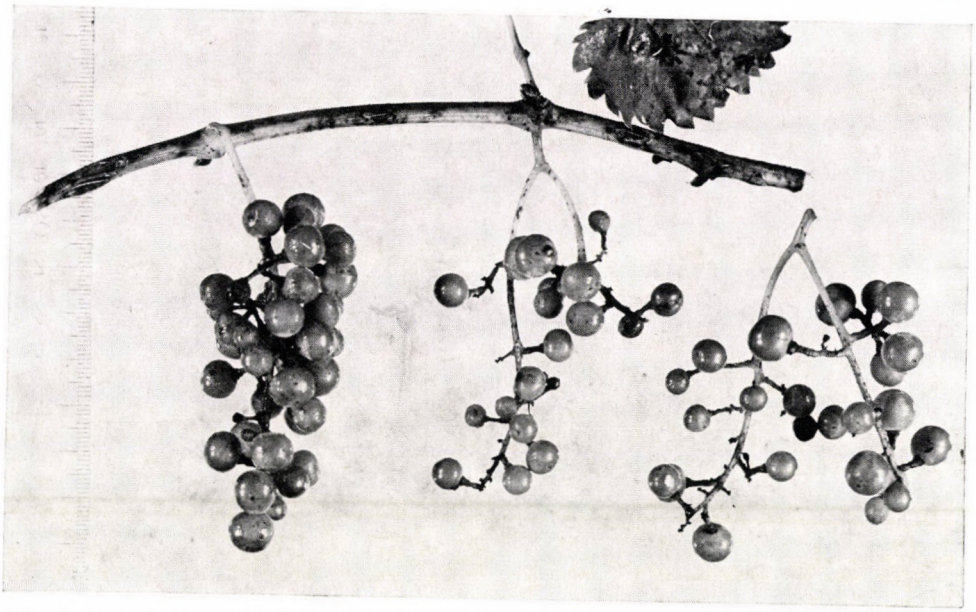


Fig. 5. Branched-winged clusters of *Vitis sylvestris* Gmel.; the fruit gathered in October, 1975, was still unmatured (green); Csőszpuszta, Bakony Mts. (photo: H. B.)

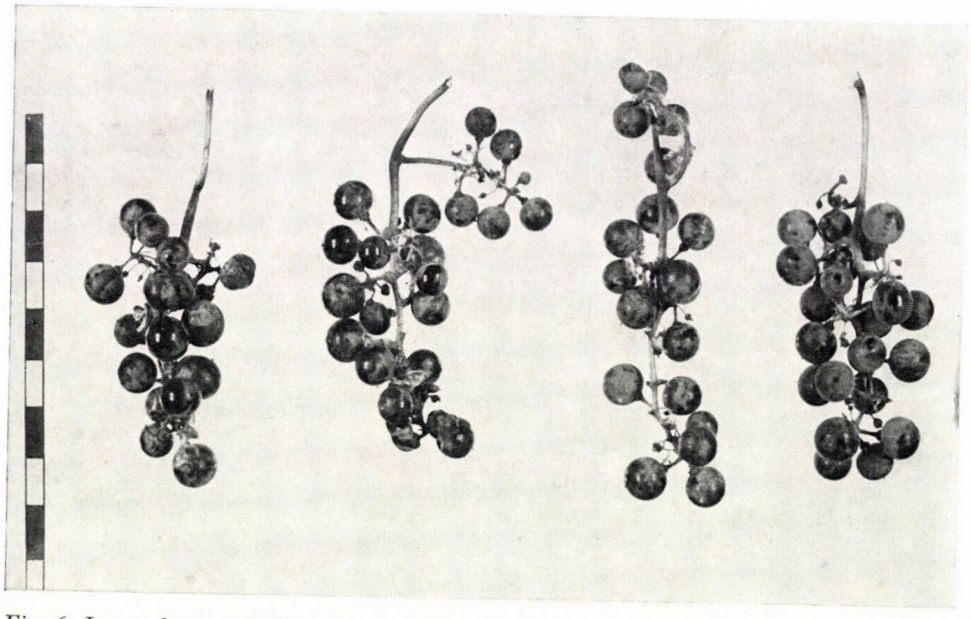


Fig. 6. Loose clusters of *Vitis riparia* Michx.; September 1975; willow groves along the river Tisza; Csongrád (photo: H. B.)

are to be found mostly in *V. riparia* (Fig. 7). The clusters of both species are usually aliform (with developed side- clusters); from the sometimes bifurcated branches twin-clusters develop (the right-side clusters in Fig. 5); the length of the clusters is variable, and it is usually characteristic of the individual plants. Clusters of 17 cm length together with the pedicel of the berry (2—5 cm) are found only in a few specimens of *V. sylvestris* and *riparia*.

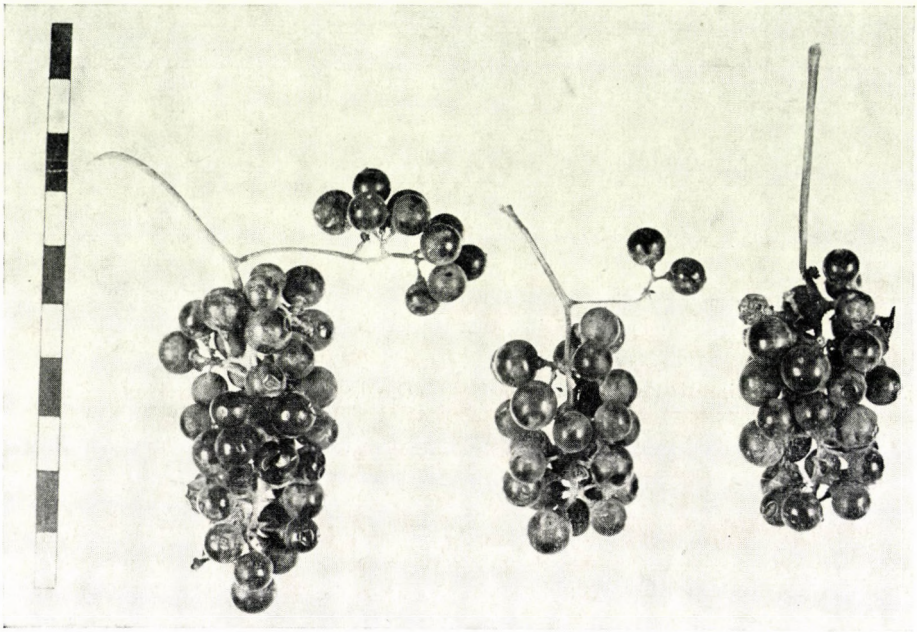


Fig. 7. Dense, winged clusters of *Vitis riparia* Michx.; September 1975; willow groves along the river Tisza; Csongrád (photo: H. B.)

In both species the clusters are generally 3.5—10 cm long. One shoot mostly bears two clusters, but three clusters may also occur. For example, in one of the specimens of *V. sylvestris* occurring in the Zemplén Mountains, clusters by shoots were found in the following numbers: 2, 3, 2, 3, 2, 2, 2, 3, 2, 2, 2, 2, 1, 2, 2, 2, 2, 2, 3.

The variance of the cluster-length is significant. In *V. riparia* it is between medium and strong variability ($s\% = CV = 21.3\%$), in *V. sylvestris* it is even greater than that ($s\% = 37.9\%$).

The total number of berries was also determined; this, in most cases, shows a small value, which can be traced back to the loose-type of cluster, and of course, to its relative smallness. In Table 1 some data are given compared to those of *V. vinifera* species. (The data of the latter are taken from the ampelograph of NÉMETH, 1967.)

The berry number of *V. riparia* given in the above table is extremely characteristic of the wild-growing stand, which is clearly demonstrated also by Figs 6 and 7. There are even greater deviations than that, when berry numbers attain 70—100 (*e.g.* in the case of a few *V. riparia* along the Danube).

In the case of both wild-growing species, the variance in berry number is greater than that experienced with regard to the clusters. The variation coefficient of *V. sylvestris* ($s\% = 47.3\%$) basically shows wide fluctuation; in reality, deviations from the average to such a large extent are frequent even within the individual plants.

Berry sizes and weights are also characteristic of the two wild species (Tables 1 and 2). The variation coefficients of both *V. sylvestris* and *V. riparia* show that the length and diameter values are of greater stability. It is interesting that the variation coefficient of the diameter shows a smaller significance in both species (in *V. sylvestris* 10.2%, in *V. riparia* 9.6%; while the length values are 14.2% and 11.6% respectively).

In Table 2, we give data of *riparia* vines from Danube-banks (with one exception); their berries are to a certain extent larger than those of the plants from Tisza-banks. In Hungary the mean value does not surpass 8 mm even in this comparison, accordingly it may be inferred that the berry size of *V. riparia* stands is generally between 6 and 8 mm.

The mean berry size of *V. sylvestris* appears to be above 8 mm. This, even within one plant, may reach 10 mm in length or diameter; *e.g.* the *V. sylvestris* plants growing along the Danube below Budapest Háros (S-2 in Table 2) have fruit length and diameter values related to data from 100 berries can be given as follows: $l = 10.9 - 6.5$, $d = 10.8 - 6.0$.

Berry weight usually show a correlation with the length and diameter data. Flesh in the *V. sylvestris* forms is of a greater weight than in *V. riparia* (this will be seen later on, at the evaluation of the seeds). We should mention only incidentally that, since the berries belonging to a cluster weights are very low.

Weight of one cluster

V. sylvestris	No. H. 100	12 g
	No. H. S-2	20 g
V. riparia	No. H. 105	12 g
	No. H. 104	20 g

Among the cultivated vines appearing in our tables, 'Chardonnay blanc' has a 69 g mean cluster weight, while 'Cabernet sauvignon' 59 g.

Among the shape characteristics of the berries, we use habitus to characterize the category. Table 2 provides data on the length and diameter of the berry, and from these we can infer that our wild vines have globular, slightly flattened berries. Slightly oblong berries (they are usually of a drop-shape) were found in a few of Danube-side *V. sylvestris*.

Table 1

Comparison of the diagnostic characters of Vitis sylvestris and V. riparia clusters with the data of a few cultivated vine cultivars

Name of species	Length of cluster, cm	Type of cluster	No. of berries
Vitis sylvestris			
Szentlőrinc No. 1	7.6	Loose+cluster branch	60
Szentlőrinc No. 3	3.5	Dense	12
Szentlőrinc No. 4	6.0	Dense+cluster branch	31
Szentlőrinc No. 5	5.2	Dense+cluster branch	26
Botykapeterd-63	8.8	Very loose+cluster branch	39
Nagypeterd U-63	8.9	Very loose+cluster branch	35
Háros S-2	12.0	Very loose+cluster branch of 7–8 cm	60
Average and standard deviation			
$(\overline{X}+s_{\bar{x}})$	*7.4±2.81*		*37±17.53*
$s\%$	*37.9%*		*47.3%*
Vitis riparia			
Háros No. 8-75	10.0	Loose+ cluster branch	43
Háros No. 13	7.3	Loose+cluster branch	38
Papsziget No. 15-74	7.8	Dense	38
Papsziget No. 41	5.0	Cylindrical-Dense	21
Papsziget No. 79	6.2	Loose-cylindrical	33
Csongrád-75	7.0	Loose- cluster branch	24
Mindszent No. 8	8.0		31
Average and standard deviation			
$\overline{X}\pm s_{\bar{x}}$	*7.3±1.56*		*32±7.93*
$s\%$	*21.3%*		*24.7%*
Vitis vinifera			
Medoc noir	12.0	Dense	50
Chardonnay blanc	12.0	Dense	54
Cabernet sauvignon	14.0	Loose-branched	66
Kövidinka	14.0	Dense	99
Kadarka	15.0	Dense	76
Kékfrankos	15.0	Dense	107
Average and standard deviation			
$\overline{X}\pm s_{\bar{x}}$	*13.6±1.36*		*75±23.44*
$s\%$	*10%*		*31.2%*

$s\% = CV$ = variation coefficient

Table 2

Size and weight of berries

Name of species	Berry size, mm		Weight of 100 berries, g
	L	Dia	
Vitis silvestris			
Szentlőrinc No. 1	8.8	9.1	42.00
Szentlőrinc No. 2	7.6	7.8	30.00
Szentlőrinc No. 3	9.5	9.5	52.16
Szentlőrinc No. 4	9.6	9.4	52.98
Szentlőrinc No. 5	8.3	9.2	33.16
Botykapeterd-63	9.1	9.3	50.21
Nagypeterd U-63	8.5	8.6	38.84
Kacsóta No. 2	9.1	8.7	44.84
Kacsóta No. 5	8.2	8.6	34.72
Simonfa No. 18	6.4	6.8	16.66
Háros S-2	8.6	8.3	40.00
Háros (Hybrid) No. 15-68	11.6	10.3	56.00
Average and standard deviation			
$(\overline{X} \pm s_{\bar{x}})$	*8.7±1.24*	*8.8±0.9*	*40.96±11.33*
$s\%$	*14.2%*	*10.2%*	*27.6%*
Vitis riparia			
Háros No. 6-64	7.7	8.1	31.68
Háros No. 13	7.4	7.4	29.30
Papsziget No. 5-63	8.9	8.9	38.88
Papsziget No. 6	8.5	8.5	45.08
Papsziget No. 8	8.4	8.6	39.96
Malomszög No. 110	6.4	6.9	24.21
Average and standard deviation			
$(\overline{X} \pm s_{\bar{x}})$	*7.8±0.91*	*8.0±0.77*	*34.85±7.75*
$s\%$	*11.6%*	*9.6%*	*22.2%*
Vitis vinifera			
Medoc noir	15.5	14.1	180.00
Chardonnay blanc	14.0	13.7	150.00
Cabernet sauvignon	13.7	12.8	120.00
Kövidinka	16.2	15.3	180.00
Kadarka	14.8	14.3	160.00
Kékfrankos	14.8	14.4	170.00
Average and standard deviation			
$(\overline{X} \pm s_{\bar{x}})$	*14.8±0.92*	*14.1±0.82*	*160.00±22.80*
$s\%$	*6.2%*	*5.8%*	*14.2%*

Comparing the data given in Table 2, a correlation between berry sizes and weights may also be inferred. This supposition has been confirmed also by the calculation of the SPEARMAN-type rank-correlation coefficient. The significance analysis of the berry length and berry weight correlation shows that the correlation is close in both species.

In the case of *V. sylvestris*, the calculated r between the two features is $+0.979$, which is considerably greater than the r value (0.5760) given at a probability level of $P = 5\%$ for the statistical control of the rank-correlation coefficient. A similarly close correlation can be stated when examining the correlation between berry diameter and berry weight, although this value is to a certain extent smaller than the previous one. In this case, the value of the rank-correlation coefficient r, at a probability level of $P = 5\%$, is $+0.853$, which is again higher than the value given for its statistical control ($r_{5\%} = 4.227$).

Comparing berry lengths and berry weights of *V. riparia*, the result is also significant but not so close. The calculated $r = +0.828$ is higher than the r value given at $P = 5\%$ probability level (it is 0.8114). It is remarkable that no correlation exists between berry diameter and weight already at $P = 5\%$ level. According to the correlation, the calculated $r = +0.7714$ value is greater than the given value ($r_{10\%} = 0.7293$) at the probability level mentioned.

The examined correlations call attention to the fact that in the growing of the vine berry, the berry weight may considerably increase with the increase in length, which is experienced primarily with cultivated vines. As will be seen later on, the increase in the seed number or seed weight is never of such a great extent as that of flesh.

The colour of vine berries is blue, black or bluish black; this is characteristic of the basic species of the *Vitis* genus. The berries of our two main wild vine species are often pruinose and this waxy cover almost entirely deface the original colour of the berry. Therefore, the *V. riparia* fruits are often of a sky-blue colour. The fruit wall is usually plain (unsculptured) and more rarely, tiny para-flecks (dotted) are sporadically found in certain forms. In describing the berry, we use the size of the pistil remains (stigma); it is especially developed in certain *V. riparia* forms. In Hungary no forms of white berries have been found. On my wild vine study tour in Yugoslavia I could gather extremely tiny, white-coloured *V. sylvestris* fruits from the karst area above Kotori. TURKOVIĆ (1955) reported the occurrence of *V. sylvestris* plants with white berries growing in other areas of Yugoslavia

The fruit of *V. sylvestris* is pleasant acidic to the taste. The berry of *V. riparia* is of characteristic "labrusca" taste, often of "grass-taste" more rarely it is sweetish; its flesh is "jelly-like" in character, the quantity of juice obtainable from it is very small; its skin is tough. The stands of *V. sylvestris* include both thin and tough skin forms.

The seed

The characteristics of the seed of vine plants, especially in connection with the origin of *V. vinifera* species, have been studied by very many authors, like ANDRASOVSZKY (1915, 1926), GOETHE (1881, 1887), FACSAR (l.c.), KIRCHHEIMER (1939; 1955), BARANOV—NEGRUL'—FROLOV (1955), KRIMPAS (1943), LEVADOUX (1956), IANOUCHIEVITCH-PELIACH (1971), PRATT (1971), SCHIEMANN (1953), NEGRUL' (1946; 1960; 1968), VASSILCZENKO (1947), POTEBNJA (1911), etc. It is indeed for the first time that data has been published on the seeds of wild vine stands in Hungary, of course, without a claim of completeness.

In taxonomic works, investigating the evolutionary state of vines, the diagnostic value of the vine seed, in contrast to the other organs of the plant, is still considered primary even today (*e.g.* LEVADOUX, l.c.; NEGRUL' l.c.).

According to the basic equation, in the pistil of the vine, in the two-carpelled and two-celled ovary, 2-ovuled cells are differentiated; from this, theoretically, giving rise to four seeds. The pistil may consist of three carpels also in our wild vines; accordingly a total of six seeds develop. In both vine species, very rarely 6 seeded berries can be found. The number of seeds per berry naturally influences the outline of the seeds to a considerable extent, which is given in Fig. 8.

It is clearly observable also in the previous figure that the regular dorso-ventral character of the vine seeds (in the case of 1-seeded berries) becomes distorted in the case of 2-seeded berries. The extent of the distortion depends also on whether the seeds have developed from both ovules of only one cell or from one ovule of each cell (Fig. 8). The situation is slightly analogous with regard to the 3-seeded berries. The approaching of the basal placentation to the pedicel of the berry, or its moving off, can be noticed in the ovary, effecting also the shape of the fruit.

The sizes of the shape characteristics, and of the sculptural elements of the surface were determined on the basis of the sketch given in Fig. 9. I have taken into consideration the seed classification which has been used so far in the literature, so that the data obtained until now in wild vine research could be compared with those of my own research. Similarly, when using terms describing shape characteristics and parts of the seed, I endeavoured to choose a terminology corresponding to that used in ampelography and botany.

Several authors have given a summary of the role played by seed characteristics in systematization and of the taxonomical value of the individual characteristic. By PLANCHON (1887), the seeds of the *Vitis* genus possess typical and permanent features of the species. In speaking about ancient types the following features are of diagnostic value: (1) small size, (2) glob-

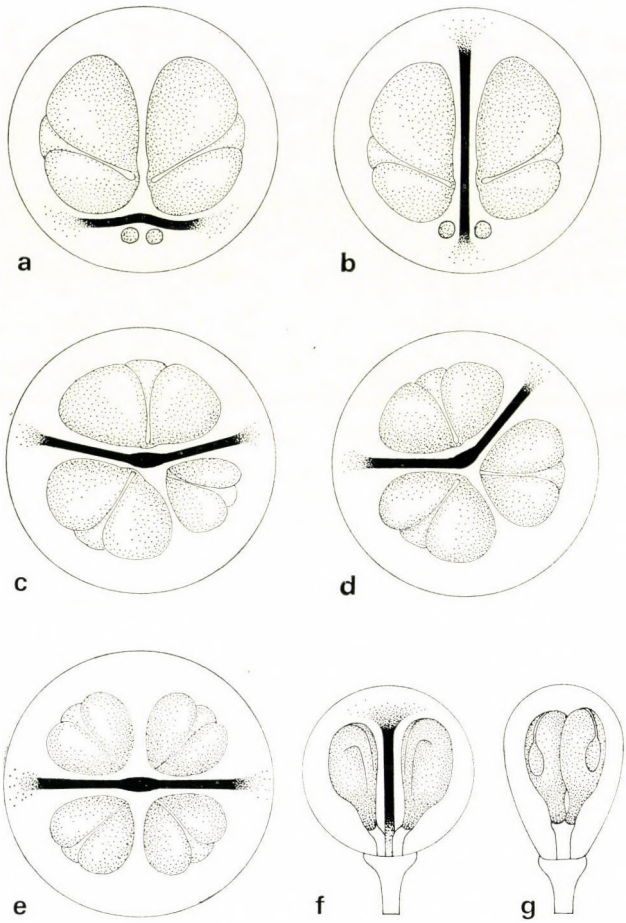


Fig. 8. Conditions of vine seeds (top and side view) in matured berries: *a* two seeds have grown in one cell of two-seeded berry; *b* two-seeded berry with one seed by cell; *c—d* three-seeded berries; *e* characteristic four-seeded "wild vine berry" of regular growth; *f—g* the position of the seeds in the placentation of various "heights" (drawing by I. KISS)

ular form, (3) short beak (—1 mm), (4) shape of chalaza (round), its sharply outlined, central position on the seed.

At the beginning of the century, POTEBNJA (1911) and STUMMER (1911) dealt with the classification of the diagnostic values of vine seeds. STUMMER was the first to focus attention on seed length and diameter in distinguishing between *V. vinifera* and *V. sylvestris*.

Although it was the grape cultivar-taxonomical value of the seeds of the *V. vinifera* that was examined by POTEBNJA (l.c.), still we shall have to consider him as an author who was the first to determine and classify those features of the vine seed which are also significant in the "natural" classifica-

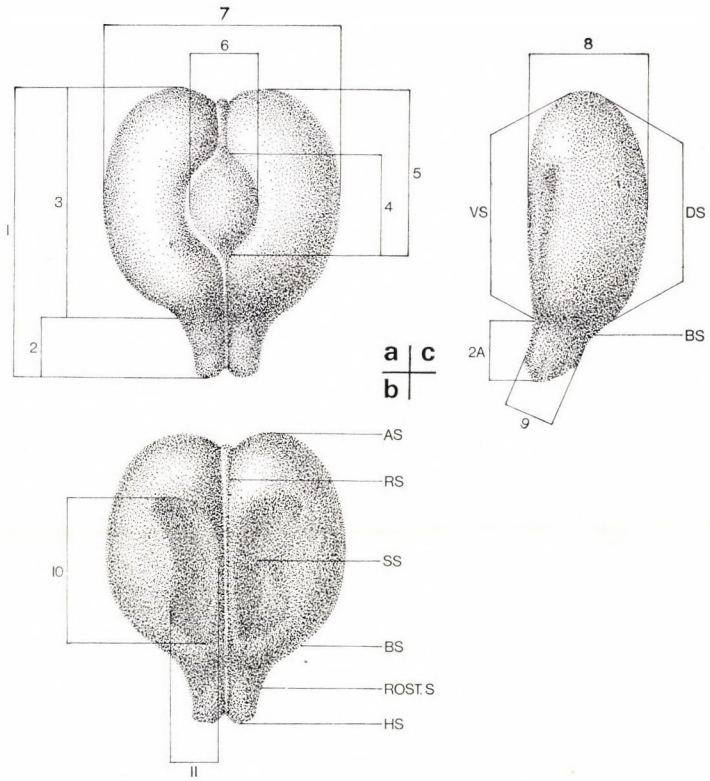


Fig. 9. Sketch of a vine seed and seed sizes. *a* Dorsal side, *b* ventral side, *c* profile (side view); *1* LS: total length of seed, 2 LROST: beek length, 2A LROST-P: beak length from profile view, *3* LCO: corpus length; *4* LSCH: length of chalaza scutate; *5* LCH: total chalaza length; *6* BRCH: breadth of chalaza scutate; *7* DIAS: total diameter of seed; *8* TH: thickness of seed; *9* THB: thickness of beak; *10* LSS: length of fossette; *11* BRSS: breadth of fossette; AS: apex of seed; DS: dorsal side; RS: raphe line; SS: fossette; BS: base of seed; HS: hilum of seed; ROST-S: rostrum of seed; VS: ventral side

tion. He used the following diagnostic characteristics in the classification of cultivars:

(1) seed weight,
(2) seed length,
(3) seed diameter,
(4) seed size,
(5) form and place of the chalaza,
(6) raphe,
(7) fossette,
(8) seed outline,
(9) form and size of the beak.

POTEBNJA elaborated 28 *V. vinifera* cultivars and on these bases compiled their cultivar system. He also distinguished a typical, so-called "Euro-

pean" group, and determined the basic diagnostic characteristics of the *V vinifera* seed. His work is essential even today, and I myself also relied on it.

Among the French authors, VIALA and PÉCHOUTRE (1910), then later on RODRIGUES (1953) deal mainly with the American species among the wild species, but they also published data referring to *V. sylvestris*.

ANDRASOVSZKY (1915; 1917) also attempted to determine a *V. vinifera* cultivar system on the basis of the diagnostic features of the seeds. He considered the following features characteristic and evaluable in the systematization:

(1) for group characterization: general shape of seed, depending on the shape of the corpus and the beak of the seed; volume and size of seed, expressed in weight; length and diameter of seed (mm); ratio of seed length and diameter;
(2) for the characterization of the various cultivars: seed colour, position and shape of chalaza, fossettes, profile of seed.

The diagnostic values of the seeds of wild vines and cultivars were dealt with in several publications by NEGRUL' (1946; 1958; 1960; 1965). According to him, the most important characteristics of the seed are the measures of the corpus (length and diameter), and of the beak, the form of the chalaza and sculpture of the fossette.

In Hungary, the seed data of *V. vinifera* cultivars are used for the cultivar grouping by NÉMETH in the ampelographical series published recently (1966; 1970; 1975).

In the subsequent paragraphs I shall evaluate the following characteristics of *V. sylvestris* and *V. riparia* seeds: (1) size based on length and diameter, (2) beak length (3) corpus length (4) chalaza length, (5) diameter of chalaza scutate; among the qualitative characteristics: (6) habitus (general outline), (7) beak properties, (8) dorsal- and (9) ventral-side sculpture (see also Fig. 9).

Seed size

Since STUMMER's publication (1. c.) the size of the seed is given as the diameter/length or length/diameter index. STUMMER also defined the seed characteristics of *V. sylvestris:* the seed of the *grove vine* is small, robust with rounded outline or is cordate, and the seed beak is almost completely missing. On the other hand, the seed of *V. vinifera* is large, elongated, ovate or pyriform, having a well-elongated beak.

KIRCHHEIMER (1955) was the first to describe in detail the data of *V. sylvestris* seeds obtained from the Danube-banks near the borders of Hungary (environs of Lobau and Eckartsau, east of Vienna).

	Length	Diameter
Lobau	4.2—6.6	3.0—5.6
Average	*5.7*	*4.1*
Eckartsau	4.4—6.4	2.7—4.9
Average	*5.6*	*3.9*

KIRCHHEIMER also elaborated the seeds of *V. sylvestris* obtained from the Upper-Rheine and he stated that they do not essentially differ from those obtained from Danube groves of Lower-Austria. For a comparison, his data referring to the length and diameter of *V. sylvestris* seeds obtained from the Upper-Rheine habitat area are given below.

	Length	Diameter
(1) Schwetzingen		
(Ketsch)	4.3—7.0	2.5—4.8
Average	*5.4*	*3.8*
(2) Germersheim		
(Hördt)	3.0—6.4	2.6—3.9
Average	*5.3*	*3.9*
(3) Speyer		
(Otterstadt)	3.5—5.7	3.0—4.5
Average	*4.9*	*3.7*

In the interest of a complete comparison, I consider it necessary that a few data should be presented also on the seeds of the wild-growing stands of the northern boundaries of the distribution of *grove vine*, or more exactly from the Eastern-European areas. The botanical investigations into *V. sylvestris* growing in the Moldavian areas of the Soviet Union have been completed recently (IANOUCHIEVITCH and PELIACH 1971). The authors carried out the processing of data by means of NEGRUL's method. The *V. sylvestris* data were gathered from vines growing in the groves alongside the rivers Pruth and Dniester. In the vicinity of the Danube mouth, only a few of the wild-growing vines were examined.

The average length of the seeds obtained from the 16 *V. sylvestris* samples that have been analyzed is 5.2 mm, their mean diameter is 3.9 mm, the mean beak length is 0.67 mm, the average length of the seed corpus without beak is 4.5 mm. Incidentally, NEGRUL' (1960) gives the seed length of *V. sylvestris*

— in a comparison with that of the *V. vinifera* cultivar groups — as 5.00 mm (4—6 mm).

The *V. sylvestris* specimens whose seed lengths are below 5 mm are in minority among those obtained from the wild vine establishments of Hungary (Tables 3 and 4). There are only two such plants in the material obtained from Kesztölc (Pilis Mountains), and there is only one in the samples each obtained from Simonfa (Zselicség) and from Szendehely (in the Naszály Mountain, north of Vác), the length values of which are low (Table 4). The average values are almost identical with the seed values obtained from the habitats in the

Table 3

Main data of V. sylvestris seeds obtained from habitats of Hungary, compared with a few data of specimens received from abroad (Bulgaria, France, German Republic), in mm

The habitats in Hungary are grouped as:

(1) Pilis Mts. (Nos 1—3); (2) Naszály Mt. south of Börzsöny (Nos 4—9); (3) Bakony Mts. (Nos 10—11); (4) Zselicség southern edge of the South-Transdanubian Hills, between Szigetvár and Pécs (Nos 12—15); (5) the northern edge of the Zselicség, south of Kaposvár (Nos 16—19); habitats along the Danube: from Mosonmagyaróvár to Budapest (Nos 20—24)

No.	Label of the specimens	LS	DIAS	LROST	LCORP	LCH	BRCH	No. of seeds
	Vitis sylvestris							
1.	Kesztölc No. 4	6.11	3.91	1.15	5.05	2.72	1.29	50
2.	Kesztölc No. 14	4.94	3.73	0.77	4.14	2.15	1.34	12
3.	Kesztölc No. 35—68	4.32	3.86	0.56	3.76	2.08	1.08	25
4.	Szendehely No. 4/a	5.46	3.80	0.84	4.60	2.56	1.48	25
5.	Szendehely No. 4/c-I	5.23	3.68	0.98	4.22	2.40	1.33	25
6.	Szendehely No. 4/c-II	4.88	3.53	0.83	4.03	2.23	1.15	40
7.	Szendehely No. 10	5.68	3.67	0.97	4.70	2.45	1.47	25
8.	Szendehely No. 10/a	5.69	3.92	0.89	4.78	2.36	1.24	25
9.	Szendehely No. 17	5.54	3.60	0.90	4.56	2.59	1.29	25
10.	Csőszpuszta No. 10	5.64	3.54	1.37	4.24	2.69	1.36	95
11.	Csőszpuszta No. 9	5.07	3.50	0.84	4.25	2.42	1.32	105
12.	Botykapeterd S-III-68	5.44	4.05	0.82	4.66	2.72	1.39	100
13.	Nagypeterd	5.61	3.64	1.24	4.33	2.39	1.17	25
14.	Szentlőrinc	5.71	4.18	0.94	4.87	2.92	1.49	25
15.	Szentlőrinc No. 22	5.10	3.71	0.78	4.31	2.26	1.12	37
16.	Simonfa No. 1	4.85	3.77	0.76	4.09	2.46	1.24	25
17.	Simonfa No. 24	5.54	4.20	0.90	4.77	3.09	1.28	100
18.	Simonfa No. 51	5.51	4.02	0.98	4.56	2.73	1.41	25
19.	Simonfa No. 53	6.17	3.67	1.24	4.87	2.81	1.11	25
20.	Feketeerdő No. 4	5.71	4.24	1.09	4.55	2.48	1.46	25
21.	Papsziget No. 1-S-II-68	5.95	3.87	1.31	4.63	2.91	1.37	25
22.	Alsógöd No. 3-S-VI-68	5.80	4.23	1.05	4.74	3.01	1.38	25
23.	Háros No. 2	5.78	3.94	0.99	4.79	2.24	1.24	66
24.	Háros No. 100	5.78	4.18	1.04	4.73	2.93	1.40	128
	Average	*5.51*	*3.70*	*0.97*	*4.54*	*2.63*	*1.32*	1083
	$(\bar{X} \pm s_{\bar{x}})$	*±0.44*	*±0.23*	*±0.19*	*±0.32*	*±0.28*	*±0.12*	
	$s\%$	*8.0%*	*6.4%*	*19.9%*	*7.1%*	*10.8%*	*9.2%*	

(LS = Length of seed, DIAS = Diameter of seed, LROST = Length of rostrum, LCORP = Length of seed corpus, LCH = Length of chalaza, BRCH = breadth of chalaza scutate; Fig. 9)

(Table 3 cont.)

No.	Label of the specimens	LS	DIAS	LROST	LCORP	LCH	BRCH	No. of seeds
	Bulgaria[1]							
	BG_Kam. No. 1	4.88	3.65	0.91	3.96	2.25	1.18	31
	$(\bar{X} \pm s_{\bar{x}})$	±0.26	±0.26	±0.16	—	±0.33	±0.07	
	$s\%$	5.3%	7.1%	18.1%	—	14.7%	6.1%	
	France[2]							
	FR_No. L-31	5.44	3.59	1.07	4.37	2.62	1.29	48
	$(\bar{X} \pm s_{\bar{x}})$	±0.38	±0.25	±0.18	—	0.32	±0.14	
	$s\%$	7.1%	7.2%	17.3%	—	12.5%	11.3%	
	German Federal Republic[3]							
	Alzey-Mi. No. 1, 2, 3	5.27	3.97	0.94	4.33	2.29	1.47	18
	$(\bar{X} \pm s_{\bar{x}})$	±0.32	±0.14	±0.15	—	±0.28	±0.12	
	$s\%$	6.2%	3.6%	16.4%	—	12.4%	8.4%	
	Alezy-N. No. 1, 2, 3	4.86	3.79	0.85	4.00	2.03	1.33	23
	$(\bar{X} \pm s_{\bar{x}})$	±0.26	±0.20	±0.15	—	±0.30	±0.12	
	$s\%$	5.5%	5.4%	18.0%	—	15.1%	9.0%	

1 The seeds were collected by J. FÖDELMESI;
2 The seeds were sent by J. P. DOAZAN;
3 The seeds were sent by F. SCHUMANN

Danube-banks of Lower Austria and in Schwetzingen of the Upper Rheine region. On the other hand, the seed length values of the few living vine plants growing along the Danube in Hungary (Nos 20—24 in Table 3) are to a certain extent higher. However, it seems that the values of the foreign specimens mentioned above surpass our values in seed diameter.

The end length groups in the *V. sylvestris* species can be established as the following limit values: up to 4.5 mm they are considered small seeds, 4.5—5.5 mm medium-sized seeds, above 5.5 mm large seeds. (The *V. vinifera* categories cannot be used.) Thus, among the 24 specimens, 15 falls into the group of large seeds, 8 belong to the medium-sized, and 1 to the small-sized category. The data processed by KIRCHHEIMER (l.c.), and those included in our Table 3, also belong to the *V. Sylvestris* category of medium or large-sized seeds.

The thickness of *V. sylvestris* seeds has been dealt with only by a small number of authors: we have taken the data and processed them but for the time being we do not intend to publish them. The data related to the seed beak of view, one of the most appreciated organs of the seed has up to now been the beak (POTEBNJA l.c., NEGRUL' l.c.). It was especially NEGRUL' (1960) who dealt much in detail with the importance of the beak in its evolutionary context. He testified by means of archaeological data that the beak grew unproportionately faster than seed length under the effect of cultivation and selection (Plate III).

Table 4

The main data of V. riparia seeds obtained from habitats in Hungary in comparison with the data of cultivated V. riparia seeds from France and of the seeds of two understock vine plants used in Hungary

No.	Label of specimens	LS	DIAS	LROST	LCORP	LCH	BRCH	No. of seeds, piece
	V. riparia							
1.	Papsziget No. R-II/68	3.96	3.35	0.43	3.56	2.03	0.86	100
2.	Háros No. 21/68	4.50	3.51	0.65	3.87	2.46	1.07	100
3.	Háros No. 22/68	4.51	3.50	0.64	3.91	2.34	1.01	100
4.	Háros No. 27/68	4.41	3.41	0.59	3.83	2.20	0.87	81
5.	Háros No. 27/68–VE	4.37	3.56	0.49	3.89	1.99	0.86	25
6.	Háros No. 23/68	4.64	3.61	0.67	3.98	2.49	0.89	100
7.	Háros No. 24/68	4.63	3.70	0.67	3.99	2.43	0.91	83
8.	Háros No. 25/68	5.15	3.87	0.71	4.47	2.60	0.84	100
9.	Háros No. 26/68	4.81	3.40	0.76	4.08	2.56	1.02	100
10.	Háros No. 3/75	4.54	3.37	0.65	3.93	2.30	0.83	186
	Average	*4.57*	*3.51*	*0.64*	*3.95*	*2.36*	*0.91*	*975*
	$(\bar{X} \pm s_{\bar{x}})$	*±0.33*	*±0.16*	*±0.09*	*±0.22*	*±0.21*	*±0.08*	
	$s\%$	*7.4%*	*4.7%*	*15.5%*	*5.8%*	*8.9%*	*9.4%*	
	France[1]							
	Fr No. 10,715	5.30	3.93	0.55	4.75	2.95	1.08	88
	$(\bar{X} \pm s_{\bar{x}})$	±0.28	±0.31	±0.08	—	±0.31	±0.14	
	$s\%$	5.3%	8.1%	15.4%	—	10.7%	13.3%	
	Under-stock vines[2]							
	No. 1616. C.	4.37	3.75	0.57	3.80	2.32	0.85	20
	$s\%$	5.8%	4.6%	22.4%	—	7.8%	18.0%	
	No. T-K. 5BB	4.11	3.41	0.59	3.52	2.20	0.77	20
	$s\%$	8.7%	4.5%	16.3%	—	12.8%	24.5%	

1 Seeds were sent by J. P. DOAZAN
2 Data by FACSAR (l. c.)

By taking in *V. sylvestris* 1 mm as the upper limit of the short beak, then 16 of the 24 specimens (67%) belong here, and 8 belong to the group of medium length (with an interval of 1.0—2.0 mm); and no specimen belongs to the group of seeds with beaks longer than 2.0 mm. The seed of the plant from Csőszpuszta (No. 10) of the Bakony Mountains has the longest beak. The data of beak length in seeds obtained from the Upper-Rheine region approach our data.

Plate III. Vitis riparia var. *syrticola*, the villosite variety, a rare plant of the groves alongside the rivers of Hungary. — Budapest, Island of Háros (drawn by Mrs. LEXA)

Plate IV. Vitis sylvestris Gmel. from the most important habitat alongside the Danube, from an Island near Alsógöd (drawn by V. . CSAPODY)

In examining the beak dimensions, a comparison with the length of the seed corpus cannot be left out of consideration. It has also been noticed that the seeds of the berries differing in seed number deviate from one another both in shape and in size. This seems to be a constant characteristic of the basic wild vine species. Therefore, right at the launching of the researches we measured in several specimens separately the seeds of the berries with different seed numbers. (See table below).

In both plants, starting from the single seeds, it can be recognized that in the elongation of the seeds, the beak grows quicker than does the seed corpus. Thus, this characteristic does already exist in the basic vine species growing wild. At the same time we also noticed such a tendency in some plants that the seed length is still significant in the two-seeded berries, then it gradually becomes smaller in the three-seeded and four-seeded berries (see our table below).

	Seed number by berry	LS mean mm	LROST mean mm	LCO mean mm	LROST/LCO	LROST/LS
12. Botykapeterd S-III-68	1 S	5.152	0.695	4.456	15	0.126
(Table 3)	2 S	5.488	0.802	4.686	17	0.135
	3 S	5.520	0.900	4.620	19	0.155
	4 S	5.628	0.920	4.708	20	0.158
17. Simonfa No. 24	1 S	5.152	0.710	4.442	15	0.131
(Table 3)	2 S	5.460	0.778	4.682	16	0.136
	3 S	5.748	0.834	4.914	17	0.141
	4 S	5.848	0.896	4.952	18	0.145
9. Háros No. 26/68.	1 S	4.296	0.668	4.628	18	0.155
	2 S	4.880	0.796	4.084	19	0.166
(Table 4)	3 S	5.080	0.792	4.292	18	0.155
	4 S	5.016	0.728	4.288	17	0.145

S = Seed, LS = Length of seed, LROST = Length of rostrum (beak), LCO = Length of corpus (See Fig. 9)

By the authors mentioned above, the diameter of the seed provide useful data, especially in connection with the diameter of the chalaza-scutate, in vine seed diagnostics. Among all the diagnostic characters in the seed it is the diameter and partly the thickness by which the various vine species are close to one another. Thus, the mean of the 48 cultivars of *V. vinifera* examined is 3.87 mm, in contrast to the *V. sylvestris* specimens where the mean is 3.70 mm.

The calculated value is influenced also by the proportion in which the seed specimens are taken from 1-, 2- or several-seeded berries. It is a general law that the seeds from two-seeded berries have the largest diameter, especially if only one seed grows per loculus, because the ventral sides of the seeds growing opposite each other become flattened which makes the seed larger in diameter (see Fig. 8).

Seed diameter in a few samples

Vitis sylvestris

12. Botykapeterd S-III-68		17. Simonfa No. 24	24. Háros No. 100
1 S	4.248 mm	4.164 mm	4.134
2 S	4.428 mm	4.424 mm	4.301
3 S	3.812 mm	3.812 mm	4.192
4 S	3.732 mm	3.732 mm	3.928

The data of the chalaza scutate diameter also provide valuable information on the nature and taxonomical value of this diagnostic character. SCHERMANN (1966) wrote that the diameter of the chalaza scutate in *V. sylvestris* is one fourth in the garden vine. He indeed got the size right concerning the diameter of *V. sylvestris* chalaza scutate, since it is on the average 36% of the seed diameter in the wild vines of Hungary; and 26% in *V. riparia*, while in the *vinifera* cultivars this value is on the average 37% (between 31% and 47%); (FACSAR, 1967).

Characteristic data were obtained when calculating the variation coefficient. The latter value shows a correlation between the two species. It is the smallest in relation to seed diameter in both species (*V. sylvestris:* 6.4%, *V. riparia:* 4.7%); the percentage variation is the greatest in the case of the seed beak length (in *V. sylvestris* 19.9%, in *V. riparia* 15.5%). The variation coefficients of the chalaza scutate diameter and length do not essentially differ in any of the species (CV = 8.9—10.8%).

Correlation between the main dimensions of the seed

In the foregoing evaluation a few of the positive and negative correlations have already been pointed out several times. Now, correlations between the most important diagnostic characters of the seed will be demonstrated by means of the traditional frequency curve mentioned above. This course will be followed mainly because it will enable us to compare our data with those found in both the West-European and East-European literatures on *V. sylvestris* seeds (see Tables 5 and 6).

Table 5

More important index numbers of V. sylvestris seeds obtained in Hungary and from abroad

No.	Label of vine	LS/ DIAS	DIAS/ LS	LROST/ LS	LCH/LS	BRCH/ DIAS	No. of seeds
	Vitis sylvestris						
1.	Kesztölc No. 4	1.56	0.63	0.16	0.44	0.33	50
2.	Kesztölc No. 14	1.32	0.75	0.16	0.43	0.36	12
3.	Kesztölc No. 35-68	1.12	0.89	0.13	0.48	0.28	25
4.	Szendehely No. 4/a	1.43	0.69	0.15	0.46	0.38	25
5.	Szendehely No. 4/c-I.	1.42	0.70	0.18	0.45	0.36	25
6.	Szendehely No. 4/c-II.	1.37	0.72	0.17	0.45	0.32	40
7.	Szendehely No. 10	1.54	0.64	0.17	0.43	0.40	25
8.	Szendehely No. 10/a	1.44	0.69	0.15	0.41	0.31	25
9.	Szndehely No. 17	1.53	0.65	0.16	0.46	0.35	25
10.	Csőszpuszta No. 10	1.59	0.62	0.23	0.47	0.38	95
11.	Csőszpuszta No. 9	1.45	0.68	0.16	0.47	0.37	105
12.	Botykapeterd S-III-68	1.34	0.74	0.15	0.50	0.34	100
13.	Nagypeterd	1.54	0.64	0.22	0.42	0.32	25
14.	Szentlőrinc	1.36	0.73	0.16	0.51	0.35	25
15.	Szentlőrinc No. 22	1.37	0.72	0.15	0.44	0.30	37
16.	Simonfa No. 1	1.28	0.77	0.15	0.50	0.32	25
17.	Simonfa No. 24	1.31	0.75	0.14	0.55	0.30	100
18.	Simonfa No. 51	1.37	0.72	0.17	0.49	0.35	25
19.	Simonfa No. 53	1.68	0.59	0.20	0.46	0.30	25
20.	Feketeerdő No. 4	1.34	0.74	0.19	0.43	0.34	25
21.	Papsziget No. 1-S-II-68	1.53	0.65	0.22	0.48	0.29	25
22.	Alsógöd No. 3-S-VI-68	1.37	0.72	0.18	0.51	0.32	25
23.	Háros No. 2	1.46	0.68	0.17	0.38	0.31	66
24.	Háros No. 100	1.37	0.72	0.18	0.51	0.33	128
	Average	*1.48*	*0.67*	*0.17*	*0.47*	*0.35*	*1083*
	Bulgaria BG—Kam. No. 1	1.33	0.74	0.18	0.46	0.32	31
	France						
	FR—No. L-31	1.51	0.66	0.19	0.48	0.36	48
	German Federal Republic						
	ALZEY—Mi No. 1, 2, 3	1.32	0.75	0.17	0.43	0.37	18
	ALZEY—N No. 1, 2, 3	1.28	0.78	0.17	0.41	0.35	23

In evaluating the correlations between the diameter and length data of *V. sylvestris* seeds, STUMMER (1911) stated that the 0.64 top value represents an almost globular seed; the extreme values are 0.54 and 0.82. The curve of the

Table 6

Characteristic indices of V. riparia seeds obtained in Hungary, in comparison with the data of two under-stock vines and of a specimen from France

No.	Label of vine	LS/ DIAS	DIAS/ LS	LROST/ LS	LCH/ LS	BRCH/ DIAS	No. of seeds
	Vitis riparia						
1.	Papsziget No. R-II/68	1.18	0.84	0.10	0.60	0.25	100
2.	Háros No. 21/68	1.28	0.77	0.14	0.54	0.30	100
3.	Háros No. 22/68	1.28	0.77	0.14	0.51	0.29	100
4.	Háros No. 27/68	1.29	0.77	0.13	0.50	0.25	81
5.	Háros No. 27/68-VE	1.22	0.81	0.11	0.45	0.24	25
6.	Háros No. 23/68	1.28	0.77	0.14	0.53	0.24	100
7.	Háros No. 24/68	1.25	0.79	0.14	0.52	0.24	83
8.	Háros No. 25/68	1.32	0.75	0.13	0.50	0.21	100
9.	Háros No. 26/68	1.41	0.70	0.15	0.53	0.30	100
10.	Háros No. 3/75	1.34	0.74	0.14	0.50	0.24	186
	Average	*1.30*	*0.76*	*0.14*	*0.51*	*0.26*	*975*
	France						
	FR No. L-31	1.51	0.74	0.10	0.55	0.27	88
	Under-stock vines[2]						
	No 1616.C	1.30	0.86	0.13	0.53	0.22	20
	No T-K. 5BB	1.20	0.83	0.15	0.53	0.27	20

vinifera distribution, which has been presented in the same graph covered to a rather large extent the area delimited by the *V. sylvestris* graph.

LEVADOUX (1956) compared the diameter/length (DIAS/LS) index of Yugoslavian seeds with the DIAS/LS distribution curve of the 'Pino franc' cultivar which stands near *V. sylvestris*. The DIAS/LS frequency curves of the two types are near each other concerning both their course and values. According to LEVADOUX, this method is nevertheless unpracticable for sharply distinguishing the two groups from each other.

The DIAS/LS index of the wild vines of Hungary has been calculated from the averages of the various specimen values since there were quite a number of data (see Figs 10 and 11). The extreme values of the *V. sylvestris* DIAS/LS index are 0.55 and 0.80, the peak value is 0.70. This maximum is identical with those of the *V. sylvestris* seeds obtained from Yugoslavia, and used by LEVADOUX (l.c., p. 70). Among the 24 specimens, 22 fluctuate between the 0.60 and 0.80 limit values, which also indic ates that uearly 92% of the seeds belongs to the various types of the globular group (Fig. 10). The maximum of the 47 *vinifera* cultivars compared is 0.55; 72% of the cultivars fluctuates

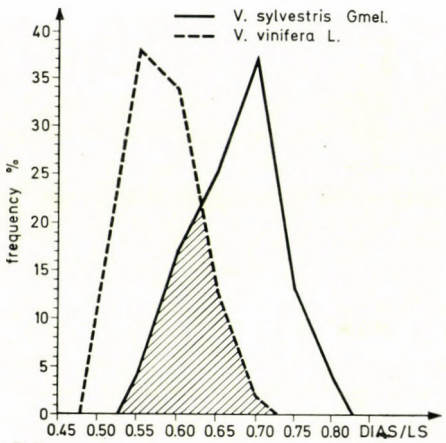


Fig. 10. DIAS/LS indices in seed specimens of *Vitis sylvestris* Gmel. stands of Hungary, in a comparison with the data of 47 wine and dessert grape cultivars grown in Hungary (data of the cultivated vines are from FACSAR, 1967)

between 0.55 and 0.64. With this method the area coverage of the two distribution curves is relatively large.

Furthermore, the *V. sylvestris* seed sizes were examined on the basis of the LS/DIAS index, *i.e.* the reciprocal of the DIAS/LS seed index. The numerical data, which have already been given in connection with the seed number per berry, were also used in making the diagram. The seed values by berry types are demonstrated first each separately then the values of the seed-

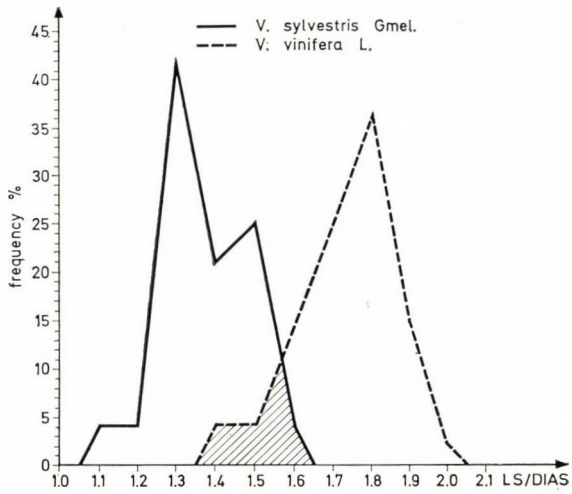


Fig. 11. LS/DIAS indices in seed specimens of *Vitis sylvestris* Gmel. stands of Hungary, in comparison with the data of 94 wine grape cultivars grown in Hungary (the cultivated vine data from NÉMETH, 1967; 1970)

number types in a common diagram of the "17. Simonfa, No. 24" *V. sylvestris* specimen (Fig. 12). Two sharper diagram peaks have been obtained, one yields a value of 1.15 by the seed data of 1-seeded and 2-seeded berries. The other, expressedly separating distribution curve is a graph of seeds obtained from 4-seeded berries and its maximum value is 1.5. The diagram of the seeds from 4-seeded berries indicates not only the relatively narrower seeds which are in cross-section sector-like in outline since 4—6 seeds grow per berry (this is a "wild vine character"), but also the shortening of the seeds.

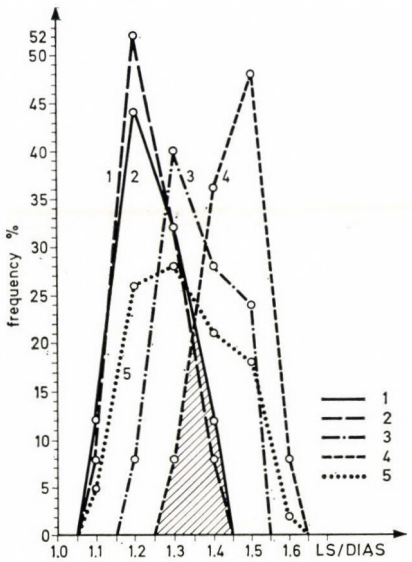


Fig. 12. LS/DIAS indices of seed number per berry in "17. Simonfa N24" *V. sylvestris* Gmel. in comparison with its cumulated LS/DIAS indices. **1** One seed per berry; **2** two seeds per berry; **3** three seeds per berry; **4** four seeds per berry; **5** cumulated indices

The distribution curve made on the basis of the average of all the specimens integrates the data into a relatively small area; in the course of the curve another, smaller, maximum also appears. This is seen on the right of the diagram of the LS/DIAS values. It calls attention to that, although in smaller number, *V. sylvestris* plants of narrower seeds also exist. I consider their occurrence as natural and it may be the consequence of the usual variability.

The extreme limit values of the LS/DIAS index fluctuate between 1.1 and 1.6; *the maximum value of the diagram is 1.3.* More than 60% of the specimens lie between 1.3 and 1.5; some 30% of the specimens is still distributed between 1.5 and 1.6.

For comparison, we have assembled from NÉMETH's Ampelograph (1967, 1970) the LS/DIAS index of 94 table grape cultivars cultivated in Hungary or occurring in collections. The distribution curve of the table grape

cultivars distinguishes well from the diagram of *V. sylvestris*. Its limit values are (1.0) 1.5 and 2.0, *its maximum is 1.8*.

The evaluation on the basis of length/diameter ratio of the size and seed shape of *V. sylvestris* plants of Hungary will probably be even more interesting and may provide more data if we compare the distribution curves with the diagrams made on the vines of Moldavia and the Crimea (Soviet Union). The localities of the vines of these two areas also are on the northern boundaries of vine growing (see Figs 13 and 14).

The length/diameter seed index data of *V. sylvestris* obtained from both areas also move between 1.1 and 1.6, and 1.5 respectively. A comparison between the maximum values of the distribution curves is also suggestive: that of the Moldavian specimens is 1.25, while that of the Crimean specimens is 1.35. The diagrams essentially show identical values with the *V. sylvestris* data of Hungary. The *vinifera* seed values concerning both the Crimean and the Moldavian plants are smaller than ours (1.65).

In the practice, the ratio number of length/diameter is also used for the grouping of seeds by shape (GOETHE, 1887; POTEBNJA, 1911; NÉMETH, 1966). The classification of *V. sylvestris* seeds by shape is as follows: —0.99 = very short (squat); 1.0—1.49 = short, above 1.50 — long, elongated; 71 per cent of our specimens belong in the short, and 29 per cent in the long (elongated) category.

No doubt may arise in connection with the taxonomic value of the beak of the seed; to this the most suitable and most expressive measure is its length, which has been measured from the top on the dorsal side and in its profile (side-view), and the averages of the data pairs were used. A frequency curve of very fine course has been obtained. It sharply expresses the character of the *V. sylvestris* beak, its different length from the vinifera cultivars (Fig. 15). Unfortunately, I had no data processed by means of similar methods abroad, so I had to decline a comparison.

On the right side of the diagram of the beak index there is a short subsidiary peak. The limit values of the distribution curve are 0.12 and 0.22; its minimum value being 0.16. The boundary values of the 47 *vinifera* cultivars used in the comparison fluctuate between 0.22 and 0.34, their maximum is 0.30. By this, the index number of the squat, very short seed beaks of wild vines is 0.14, that of the short is 0.14—0.18 (71% of our specimens can be enumerated here), while that of the long, extended beaks is above 0.18.

The length of the whole chalaza (LCH), which is measured from the peak of the seed down to the lower edge of the scutate, located towards the beak, also belongs in the diagnostic characters of the species (Fig. 9). According to the taxonomists of vine species and cultivars (NEGRUL' l.c., PLANCHON l.c.), the chalaza lies in the middle of the seeds of wild vine species, while in cultivated vines in the upper third of the seed. Other authors maintain that the chalaza

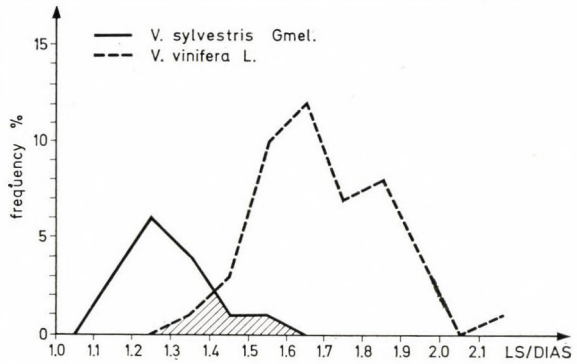


Fig. 13. LS/DIAS average ratio values of vine specimens from Moldavia (USSR)

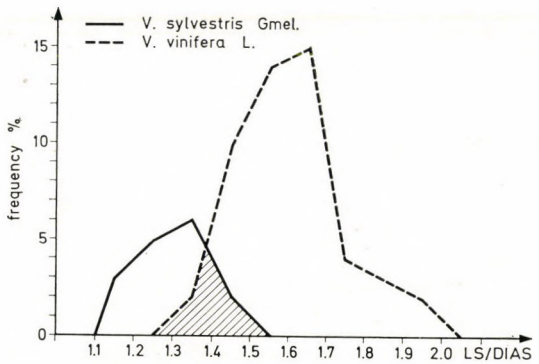


Fig. 14. LS/DIAS average ratio values of vine specimens from the Crimea (USSR)

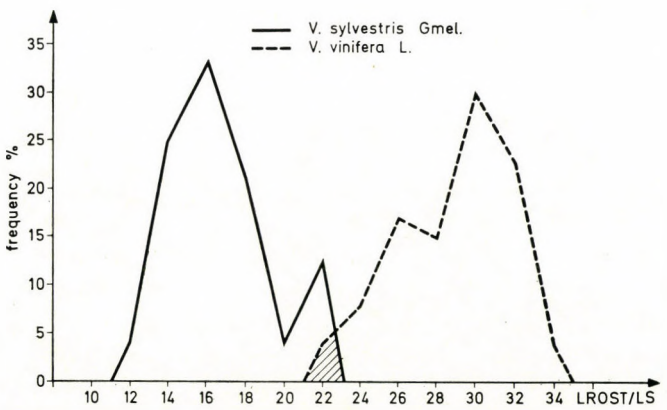


Fig. 15. Average LROST/LS indices of vine specimens of Hungary (data of 47 dessert and wine grapes)

Plate V. Vitis riparia Michx. with pruinose, bluish fruit, from the willow groves of the Pap Island of the Danube near Szentendre (drawn by V. CSAPODY)

scutate may develop in wild vines not only in the middle but also in the upper third of the seed.

On the basis of the average data it can be said that the centre of the chalaza scutate in the seeds of *V. sylvestris* of Hungary is indeed in the middle of the corpus of the seed (if the length of the beak is not considered), or it is slightly pushed towards the beak (Plates IV and V). It is only in one of our plants, in the Danube-bank vine No. 22 that the chalaza scutate is located definitely in the upper third of the seed (LCH/LS = 0.38, LCH/LCO = = 0.46). By the measured data, the location of the chalaza scutate in the *V. riparia* forms is identical with that of *V. sylvestris* (Table 4). The average of the chalaza lengths of the 47 *vinifera* cultivars (2.76 mm) examined in our Institute shows hardly any difference from that of *V. sylvestris* (2.63). In the case of *vinifera* if the long beak is also considered (the average is 2.00 mm) then in determining the location of the chalaza scutate it certainly may be said that — seemingly — it is located in the upper third of the seed corpus (FACSAR, 1967).

*

Part II of this study will be published in the next issue.

REFERENCES

ANDRASOVSZKY, J. (1915): A szőlőmagvak diagnosztikus értéke (Die Bedeutung der Traubensamen für die Unterscheidung der Sorten der Weinrebe). Borászati Lapok 47/38, 39.

ANDRASOVSZKY, J. (1917): A szőlőmagvak diagnosztikus értéke (Der diagnostische Wert der Traubensamen). Ampel. Int. Évk. (1915—1916) **6,** 49—59.

ANDRASOVSZKY, H. (1924): Vitis L. — Szőlő. (The vine.) In JÁVORKA, S.: Magyar Flóra **2,** 701—708.

BARANOV, P. A.—NEGRUL', A. M.—FROLOVA, K. I. (1955): Dikorastuščij vinograd Srednej Azii. Problemy botaniki, vyp. **2,** 74—112.

FACSAR, G. (1967): A kerti szőlő (Vitis vinifera L.) magvainak fajtarendszertani jelentősége (The systematic importance of the seeds of Vitis vinifera L.). Unpublished diss. Kertészeti Egyetem Könyvtára, Budapest.

FACSAR, G. (1970): Habitus studies on seeds of Vitis vinifera L. sorts. Acta Agronomica **19,** 403—406.

FACSAR, G. (1970): Összehasonlító morfológiai vizsgálatok kerti szőlőfajták magjain. I. (Comparative morphological examinations on seeds of V. vinifera L.) Bot. Közl. **57,** 221—231.

FACSAR, G. (1971): Összehasonlító morfológiai vizsgálatok kerti szőlőfajták magjain. II. (Comparative morphological examinations on seeds of V. vinifera L.) Kertészeti Egyetem Közl. **34,** 93—101.

GMELIN, K. CH. (1805): Flora Badensis, Alsatica et confinium . . . Karlsruhe **1,** 543—545.

GOETHE, H. (1881): Studien über die Samen der Rebenvarietäten. Ampelografische Berichte, **6,** 161—176.

GOETHE, H. (1887): Handbuch der Ampelographie. Berlin, **2.**

HEGEDÜS, Á.—KOZMA, P.—NÉMETH, M. (1966): A szőlő —Vitis vinifera L. (The vine). Magyarország Kultúrflórája, Budapest, **4/1.**.

HEGEDÜS, Á. (1968): A szőlőlevél szőrözetének diagnosztikai és rendszertani értéke (Valeur diagnostique et systematique de la villosité des feuilles de la vigne). Szől. Kut. Int. Évk. **13,** 87—104.

HEGEDÜS, Á. (1969): A szőlő (Vitis) hisztológiája, különös tekintettel a termesztés korszerűsítésére. Doktori értekezés (MTA Könyvtára) (Histology of vine, with special regard to the modernization of the cultivation). Dissertation for D. Sc. (Library of HAS)

I'SÓ, A. (1954): A Tisza-parti ripariákról (Über die Riparien längs der Theiss). Kertészet és Szőlészet **3,** 4.

JANOUCHIEVITCH, Z. V.—PELIACH, M. A. (1971): Dikorastuščij vinograd Moldavii (La vigne sauvage de Moldavie). Kišinev.

JÁRAI-KOMLÓDI, M. (1966): Palinológiai vizsgálatok a Magyar Alföldön. Kand. disszertáció, Budapest (Palynological examinations in the Hungarian Plain) Dissertation for C. Sc. Library of HAS.

JÁRAI-KOMLÓDI M. (1969): Adatok az Alföld negyedkori klíma és vegetáció történetéhez II. (Data to the climate and vegetation history of the Hungarian Plain of the Quarternary). Bot. Közl. **56,** 43—55.

KERNER, A. (1863): Das Pflanzenleben der Donauländer. Innsbruck.

KERNER, A. (1875): Die Vegetationsverhältnisse des mittleren und östlichen Ungarns. Innsbruck.

KIRCHHEIMER, F. (1939): Vitaceae. Foss. Catalogus. II. (Plantae 24, Junks'Gravenhage.

KIRCHHEIMER, F. (1955): Über das Vorkommen der wilden Weinrebe in Niederösterreich und Mähren. Zeitschrift für Botanik **43,** 279—307.

KOZMA, P. (1963): A szőlő termékenységének és szelekciójának biológiai alapjai. (The biological basis of grape fertility and selection) Akadémiai Kiadó.

KRIMPAS, B. (1943): Ampélographie hellénique 1. Athénes.

LEVADOUX, L. (1956): Les populations sauvages et cultivées de Vitis vinifera L. Ann. de l'Amélioration des Plantes. Paris, **1,** 59—118.

MAGYAR, P. (1960): Alföldfásítás (Die Aufforstung des Alfölds). Akadémiai Kiadó, Budapest, 428.

NEGRUL', A. M. (1946): Proischoždenie kulturnogo vinograda i ego klassifikacia. In Ampelografija S.S.S.R. Moskva, **1,** 159—212.

NEGRUL', A. M. (1946): Semejstvo Vitaceae Lindley. In Ampelografija SSSR. Moskva, **1,** 45—117.

NEGRUL', A. M. (1958): Dikorastuscij vinograd Krima i ego svjaz s mestnymi sortemi. Izvestija. T. S. CH. A. **1,** 39—50.

NEGRUL', A. M. (1960): Evolucija razmera semjan i jagod u vinograda. Izvest. TSHA. **2,** 167—176.
NEGRUL', A. M. (1968): Proischoždenie kul'turnogo vinograda. Doklady Timirjazevskoj S. CH. A. 139.
NEGRUL', A. M.—IVANOV, I. K.—KATEROV, K. I.—DONCEV, A. A. (1965): Dikorastuščij vinograd Bolgarii. Moskva.
NÉMETH, M. (1966): Borszőlőfajták határozókulcsa (Taxonomic key of table grape cultivars).
NÉMETH, M. (1967, 1970): Ampelográfiai Album. Termesztett borszőlőfajták (Cultivated grapevines). **1, 2.** Budapest.
PLANCHON, J. E. (1887): Ampelideae in "Monographia phanerogamorum prodromi" de A. et C. de Candolle. **V. 2,** Paris.
POP, E. (1931): Vitis silvestris Gmelin in Rumänien. Bul. Grad. Bot. Univ. Cluj II, No 3—4.
POTEBNJA, A. A. (1911): Semena evropejskich sortov vinograda i ich značenie dl'a klassifikacii. Trudy bjuro po prikladnoj botanike. St. Peterburg, **3,** 147—158.
PRATT, C. (1971): Reproductive anatomy in cultivated grapes — a review. Amer. J. Enol. Viticult. **22,** 92—109.
PRATT, C. (1974): Vegetative anatomy of cultivated grapes — a review. Amer. J. enol. Viticult. **25,** 131—150.
RÁTHAY, E. (1888—1889): Die Geschlechtsverhältnisse der Reben und ihre Bedeutung für den Weinbau. Wien, **1, 2.**
REHDER, A. (1951): Manual of cultivated trees and shrubs hardy in North America. New York, 609—616.
RODRIGUES, A. (1955): Contribution à l'étude des rapports entre le volume et la forme des grains, le nombre et le poids des pépins dans la Vitis vinifera L. In the congrès international de la vigne et du vin. Rome-Sienne, 13—20 Septembre 1973. Rapports et actes du congrès. Alençon, **3,** 107—128.
SCHERMANN, Sz. (1966): Magismeret (Understanding seeds). **1—2.** Akadémiai Kiadó, Budapest.
SCHIEMANN, E. (1953): Vitis in Neolithicum der Mark Brandenburg. Züchter, **23,** 318—327.
SCHUMANN, F. (1968): Die Verbreitung der Wildrebe am Oberrhein. Die Wein-Wissenschaft, **23,** 487—497.
SCHUMANN, F. (1971): Berichte über die Verwendung der Wildrebe Vitis vinifera L. var. sylvestris Gmelin. Die Wein-Wissenschaft, **26,** 212—218.
SCHUMANN, F. (1972): Vergleich von morphologischen und physiologischen Eigenschaften verschiedener Vitis vinifera-Sorten und -Kreuzungen. (Diss.) Bonn.
SOÓ, R. (1964, 1966, 1968, 1970, 1973): A magyar flóra és vegetáció rendszertani-növényföldrajzi kézikönyve (Synopsis systematico-geobotanica vegetationisque Hungariae). I—V. Budapest.
STUMMER, A. (1911): Zur Urgeschichte der Rebe und des Weinbaues. Mitteilung der anthropolog. Ges. in Weine **41,** 283—296.
SVÁB, J. (1967): Biometriai módszerek a mezőgazdasági kutatásban (Biometrical methods in agricultural research). Mezőgazdasági Kiadó, Budapest.
TERPÓ, A. (1960): Magyarország vadkörtéi (Pyri Hungariae). A Kertészeti és Szőlészeti Főiskola Évkönyve **22.**
TERPÓ, A. (1962): Adatok a hazai vadontermő Vitis-ek ismeretéhez (Beitrag zu den Angaben über die in Ungarn wildwachsenden Vitis-Arten). Kertészeti és Szőlészeti Főiskola Évkönyve, **26,** 147—161.
TERPÓ, A. (1963): A vadontermő gyümölcsfajok taxonómiai és növényföldrajzi kutatása Magyarországon (Die taxonomische und pflanzengeographische Erforschung der wild wachsenden Obstarten in Ungarn). Kertészeti és Szőlészeti Főiskola Évkönyve, **27,** 244—275.
TERPÓ, A. (1966): A Magyarországon vadon és elvadultan előforduló szőlőfajok határozókulcsa. In Hegedüs et al.: A szőlő — Vitis vinifera L. (Taxonomic key of the wild and feral vine species occurring in Hungary). Magyarország Kultúrflórája. Budapest, **4,** 15—16.
TERPÓ, A. (1969): A Vitis silvestris Gmel. Magyar középhegységi termőhelyi viszonyainak vizsgálata (Untersuchungen über die Standortsverhältnisse der Vitis silvestris Gmel. in Ungarischen Mittelgebirge). Bot. Közlem. **56,** 27—35.
TERPÓ, A. (1974): A ligeti szőlő (Vitis silvestris Gmel.) trichomáinak és indumentumának összehasonlító vizsgálata (Comparatory tests of trichomas and indumenta of Vitis silvestris Gmel.). Kertészeti Egyetem Közl. **38,** 304—314.
TURKOVIĆ, Z. (1961): Betrachtungen über den Ursprung und über die Verbreitung der Rebensorten. Der Deutsche Weinbau, **16,** 81—95.

TURKOVIĆ, Z. (1955): Untersuchungsergebnisse über Vitis silvestris Gmelin im Jahre 1954. Weinberger und Keller, **2,** 74—79.

VASSILCZENKO, I. T. (1947): Novyje dannyje o proischoždenii vinograda. Sovjetskaja Botanika, **15,** 338—343.

VASSILCZENKO, I. T. (1955): Novyje dl'a kul'tury vinograda. Izd. AN S.S.S.R. Moskva—Leningrad.

VIALA, P.—PÉCHOUTRE, F. (1910): Morphologie du genre Vitis. In VIALA—VELMOREL: Ampélographie. Masson, Paris, **I,** 113—298.

ZÓLYOMI, B. (1958): Budapest és környékének növénytakarója (The plant cover of Budapest and environs). In PÉCSI, M.: Budapest természeti képe (The nature landscape of Budapest). Budapest, 599—602.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1—2), pp. 249—258 (1976)

MORPHOMETRY OF SPORES AND SUBSTANTIATION OF A NEW SYSTEM IN THE GENUS AGARICUS FR. EMEND. KARST.

By

S. P. WASSER, L. V. GARIBOVA and V. L. MOKEEVA

THE N. G. KHOLODNY INSTITUTE OF BOTANY, ACADEMY OF SCIENCES, UKRAINIAN SSR, KIEV

and

THE M. V. LOMONOSOV STATE UNIVERSITY, MOSCOW

(Received December 10, 1975)

In assessing the taxonomic value of the characters of the genus *Agaricus*, 43 anatomo-morphological, cultural physiological and biochemical features have been considered. The range of variability of the spores of 49 *Agaricus* species indigenous in the Northern Hemisphere has been studied by statistical methods. Collections of exsiccates (A. H. SMITH, Herb. of the University of Michigan, U.S.A.; S. LUNDELL, Fungi exsiccati suecici praesertim Upsalienses, Sweden), samples originating from various geographical zones and type-specimens (F. H. MOELLER, Herb. Mus. Bot. Hauniense; A. PILÁT, Herb. Gen. Mus. Bot. Pragae; G. BOHUS, Herb. Musei Hist.-nat. Hung.; P. D. ORTON, Herb. Hort. Bot. Reg. Kew), as well as collections of different institutes of the Soviet Union have been studied.

An important and stable index, K_m, has been introduced: it represents the relationship of spore length to spore width and has been obtained through the measurement of 100 mature spores of each specimen. This index indicates the evolutionary progressiveness of the species. The round spores are considered to be more primitive (SINGER, 1975), therefore the species having a smaller K_m are evolutionally older than those with a bigger one. In addition, the character of the area, the number of species, the type of evolution, the structure of the trama, the variability within the species, etc. have also been considered.

The analysis of the complex of characters and the biometric study of spores suggested a new system within the genus *Agaricus*, involving four subgenera, ten sections, four subsections and ten series. A key to the identification of infrageneric taxa in the genus *Agaricus* is also given.

The necessity of special studies in variability of living beings — in particular the limits of variability in the micro- and macrostructures of agarics, the elucidation of phylogenesis complicated by a polymorphism peculiar to them, the phenomena of parallelism and homoplasia — is beyond doubt. The results of these studies may be used when solving the problems of evolution and taxonomy of the *Agaricales*.

The evidence on the morphological variability in the microstuctures of agarics are rather scanty and are of sporadic character (Зингер, 1950; Гарибова—Сафрай, 1972; DUNCAN—GALBRAITH, 1973). The main regularities of variability have not yet been studied and the ways of subsequent research have not been contemplated.

One of the reasons of this state of affairs is the insufficiently wide applications of the quantitative, and in particular, the statistical methods of study.

Though as A. G. RAITVIIR (1973) remarks, the ". . . application of even simple mathematical methods permits differentiating rather accurately the similar species already on the basis of the quantitative characters and that the quantitative characters are more reliable than certain widely used qualitative ones."

The main task when studying the genus *Agaricus*, like that of all *Agaricales*, is a critical and systematic estimation of the taxonomic value of the characters. As F. H. MOELLER (1950—1951), A. PILÁT (1951), P. HEINEMANN (1956), L. V. GARIBOVA and V. L. MOKEEVA (Гарибова—Мокеева, 1974), have shown the number of characters which can be taken into account (involving the morphologocultural and physiologobiochemical ones) when studying the species of the genus *Agaricus* may reach 42—43. Hence a problem on the objective estimation of the taxonomic significance of certain characters of the genus *Agaricus* arises. In our paper, dedicated to a study of the systematics and taxonomy of the genus *Agaricus*, a search for the taxonomically significant character was the basis. Concerning the genus *Agaricus*, this was not a chance platform. The extensive non systematized variability of the characters resulted in the fact that R. SINGER (1951) even wrote about the impossibility of constructing a working key for the identification of species in the genus *Agaricus*.

Many characters, playing the apparently leading role, are taken into account in the systematics of *Agaricales* without studying the limits of variability and this often causes the description of numerous unfounded species, non-existent in nature.

P. KONRAD—A. MAUBLANC (1948) remark apropos of this: ". . . it should not be forgotten that in the books there are much more macromycetes than in nature".

Based on the general observation that the generative organs are least subjected to the direct effect of environment, the size, shape and structure of basidiospores are considered of the greatest importance in the systematics of agarics.

Spore sizes in the species of the genus *Agaricus* are variable. Therefore, to evaluate a taxonomic significance in the spore sizes, it is first of all necessary to detect the range of their variability under natural conditions. For this purpose, specimens from different geographical zones should be compared and a study of exisccates and type-specimens would be necessary. A thorough study of the type-specimens in the source of the detailed and objective diagnosis, that is the determination of each new taxon of specific distinctness. This is the only means that a complete critical representation of the existing characters of the taxon and the range of their variability can be established.

The type-specimens of the species of the genus *Agaricus*, described by F. H. MOELLER and J. LANGE from Denmark (Herb. Museum Botanicum Hauniense Fungi Danici), A. PILÁT from Czechoslovakia (Herb. Generale Musei Bohemiae Pragae, Flora Bohemica), G. BOHUS from Hungary (Herb. Musei Hist.-nat. Hung., Budapest, Flora Hungarica), P. D. ORTON from England (Herb. Hort. Bot. Reg. Kew), the exsiccates made by SMITH (A. H. SMITH,

Herb. of the University of Michigan, USA), and by LUNDELL (S. LUNDELL, Fungi exsiccati suecici praesertim Upsalienses) as well as the collections of the species in the herbaria of the N. G. KHOLODNY Institute of Botany of the Academy of Sciences of the Ukrainian SSR, in the V. L. KOMAROV Institute of Botany of the Academy of Sciences of the USSR, in the Departments of Thallophytes of the Biological Faculty of the M. V. LOMONOSOV Moscow State University, in the Institute of Botany of the Lithuanian SSR, in the Institute of Zoology and Botany of the Academy of Sciences of the Estonian SSR, in the Institute of Biology and Soil of the Far East Branch of the Academy of Sciences of the USSR, have been the material of our studies to determine the sizes of basidiospores.

A list of all studied species of the genus *Agaricus* is given in Table 1.

The measurements were made by means of an ocular micrometer, 100 mature (coloured) spores of each specimen having been measured.

The final size of spores in each species is presented as the arithmetic mean (M_m) of the length and width — with indication of their root-mean-square deviation (δ) by E. K. MERKURYEVA (МЕРКУРЬЕВА, 1963). The arithmetic mean was calculated by the formula $M_m = \frac{\Sigma M_0}{n}$, where a sum of all values of the character is given in the numerator and the number of the spore measurements in the denominator; the root—mean—square deviation is presented by the formula

$$\delta = \sqrt{\frac{\Sigma (M_m - M_0)^2}{n - 1}}$$

The data obtained are used for the characteristics of another very important parameter, the stable index K_m.

This is a ratio of the spore length to its width. K_m was calculated from the K of each of the 100 spores.

Taking into account the limits of variability of the spores, the index K_m, differing by its stability, may be used as a criterion of the species and a rather important additional criterion of the intrageneric taxa of diverse rank.

When comparing two or more specimens from the same locality or from different geographical zones, K_m is found to be practically the same (see Table 1, the value of K_m for *A. arvensis*, *A. bitorquis*, *A. purpurellus*, *A. maskae*). K_m may be called an index of the evolutionary progressiveness of the species, since the round spores are considered to be more primitive (SINGER, 1962). Therefore species having smaller K_m are inferably older in evolution than those with larger ones. *A. bernardii*, having K_m 1.28, seems more ancient than, for example, *A. campestris* ($K_m \approx 1.63$). The evolutionary youth of *A. campestris* is also confirmed by other characters (width of area, frequency, wide polymorphism).

The values of K_m proved to be similar, to a sufficient degree, in the intrageneric taxa and in some of their species; this makes it possible to use K_m in the complex of characters as a reliable additional criterion for intrageneric classification.

Numerous classifications of the genus *Agaricus* exist (KONRAD—MAUBLANC, 1948; PILÁT, 1951; MOELLER, 1950—1951; SINGER, 1951; 1975; HEINEMANN, 1956; MOSER, 1967, Table 2); however the criteria assumed as their basis are not systematized and frequently neglected by many authors when distinguishing the intrageneric taxa of the same rank. For example in the system

Table 1

The sizes of spores and index of evolutionary progressiveness of species in the genus Agaricus Fr. emend. Karst.

Intrageneric taxa			Species	Average size of spores in		K_m of spores	K of intrageneric taxa		
				length	width		Subsections	Sections	Subgenera
1			2	3	4	5	6	7	8
Subgenus *Agaricus*	Section *Agaricus*	Subsection *Rufescentes*	*Agaricus campestris* Fr.	*6.8±0.7**	4.2±0.5	1.63			
			Agaricus campestris Fr.	6.7±0.6	4.3±0.6	1.53			
			A. cupreobrunneus (J. Schaeff. et Steer ex Moell.) Moell.	7.7±0.8	4.7±0.5	1.65			
			A. porphyrocephalus (Moell.) Moell.	5.8±0.6	3.8±0.3	1.51	1.51		
			†*A. spissicaulis* (Moell.) Moell.	7.5±0.8	5.1±0.5	1.47			
			†*A. spissicaulis* (Moell.) Moell.	6.9±0.6	5.0±0.4	1.38			
			R*A. radicatus* Vitt. ss. Romagn.	7.0±0.3	4.7±0.2	1.47			
			R*A. radicatus* Vitt. ss. Romagn.	6.6±0.6	4.7±0.4	1.42			
			†*A. bresadolianus* Bohus	6.8±0.3	4.8±0.2	1.43			
			†*A. bresadolianus* Bohus	6.3±0.8	4.1±0.4	1.67			
		Subsection *Senguinolentae*	†*A. deylii* Pil.	7.8±0.8	5.0±0.5	1.57			
			†*A. benesii* Pil.	7.0±0.4	4.5±0.3	1.55			
			†*A. caroli* Pil.	6.4±0.4	4.4±0.2	1.43			
			†*A. squamuliferus* (Moell.) Pil.	5.4±0.4	3.6±0.3	1.48		1.54	1.41
			†*A. annae* Pil.	8.4±0.9	4.9±0.4	1.71			
			†*A. altipes* (Moell.) Moell.	5.8±0.3	3.9±0.2	1.51	1.57		
			†*A. aestivalis* (Moell.) Moell.	8.1±0.4	5.2±0.9	1.55			
			†*A. langei* (Moell.) Moell.	8.7±0.8	4.9±0.5	1.80			
			†*A. fuscofibrillosus* (Moell.) Moell.	8.1±0.3	4.9±0.2	1.63			
			A. haemorrhoidarius Kalchbr. et Schulz.	6.3±0.8	3.6±0.5	1.61			
			A. silvaticus Schaeff. ex Secr.	6.2±0.6	4.1±0.4	1.52			
			A. silvaticus Schaeff. ex Secr.	4.8±0.8	3.2±0.6	1.50			
			†*A. luteolorufescens* P. D. Orton	6.3±0.5	4.0±0.1	1.53			
			†*A. vinosobrunneus* P. D. Orton	6.1±0.4	3.9±0.5	1.55			
	Section *Duploannulatae*		*A. subfloccosus* (J. Lge.) Pil.	6.0±0.6	4.6±0.3	1.31			
			A. bisporus (J. Lge.) Imbach	6.2±0.7	4.9±0.4	1.36			
			A. maleolens (Moell.) Moell.	6.5±0.5	4.8±0.2	1.35			
			A. hortensis (Cke.) Pil.	5.9±0.5	4.3±0.5	1.40			
			A. gennadii (Chat. et Boud.) P. O. Orton	6.6±0.4	5.1±0.4	1.29		1.28	
			†*A. gennadii* ssp. *microsporus* Bohus	6.7±0.3	5.1±0.3	1.30			
			A. bitorquis (Quél.) Sacc.	5.1±0.3	4.4±0.5	1.16			
			A. bitorquis (Quél.) Sacc.	5.6±0.5	4.7±0.5	1.21			
			A. bernardiiformis Bohus	6.7±0.2	5.7±0.2	1.18			
			A. bernardii Quél. ap. Cke. et Quél.	6.1±0.7	4.9±0.5	1.25			

Intrageneric taxa			Species	Average size of spores in		K_m of spores	K of intrageneric taxa		
				length	width		Sub-sections	Sections	Sub-genera
1			2	3	4	5	6	7	8
Subgenus *Flavoagaricus*	Section *Majores*	Subsection *Flavescentes*	*A. augustus* Fr. ss. auct. non Rick.	7.8±0.4	4.9±0.2	1.59			
			[t] *A. macrosporus* (Moell. et J. Schaeff.) Pil.	9.3±0.2	7.2±0.6	1.34			
			[t] *A. macrosporoides* Bohus	9.3±0.3	5.8±0.2	1.61			
			[t] *A. excellens* (Moell.) Moell.	10.2±0.8	6.2±0.5	1.67			
			[t] *A. abruptibulbus* Pk.	6.6±0.4	4.9±0.3	1.35			
			[t] *A. amanitaeformis* S. Wasser	6.1±0.6	4.5±0.3	1.26			
			[t] *A. arvensis* Schaeff. ex Secr.	6.1±0.4	4.1±0.4	1.50	1.46		
			[t] *A. arvensis* Schaeff. ex Secr.	5.7±0.7	3.7±0.5	1.53			
			[t] *A. chionodermus* Pil.	7.4±0.6	4.4±0.9	1.44			
			[t] *A. maskae* Pil.	7.3±0.4	5.1±0.4	1.44			
			[t] *A. maskae* Pil.	6.8±0.5	4.9±0.5	1.40			
			[t] *A. nivescens* (Moell.) Moell.	6.4±0.5	4.6±0.3	1.41			
			A. silvicola (Vitt.) Sacc.	6.9±0.6	4.3±0.5	1.62			
			A. tabularis Pk.	7.1±0.6	5.0±0.4	1.43		1.46	1.43
			[t] *A. osecanus* Pil.	7.0±0.6	5.2±0.4	1.36			
		Subsection *Xanthodermatae*	*A. xanthodermus* Gen.	6.2±0.7	4.0±0.4	1.55			
			[B] *A. xanthodermus* Gen.	5.9±0.3	3.8±0.4	1.53			
			[t] *A. pilatianus* Bohus	6.3±0.3	4.6±0.4	1.39			
			A. meleagris J. Schaeff.	6.1±0.5	3.9±0.2	1.58			
			[t] *A. moelleri* S. Wasser	5.0±0.1	3.1±0.2	1.53			
			A. placomyces Pk.	5.2±0.5	3.4±0.5	1.57	1.47		
			A. placomyces Pk.	5.1±0.4	3.5±0.4	1.45			
			[t] *A. velenovskyi* Pil.	5.2±0.4	4.1±0.3	1.28			
			[t] *A. phaeolepidotus* (Moell.) Moell.	5.3±0.5	3.8±0.5	1.40			
			[B] *A. pseudopratensis* (Bohus) Bohus	5.6±0.3	3.9±0.3	1.42			
	Section *(Minores)*		*A. purpurellus* (Moell.) Moell.	4.8±0.3	3.6±0.4	1.35			
			"	4.9±0.5	3.8±0.3	1.33			
			"	5.5±0.3	4.0±0.4	1.44			
				5.2±0.5	4.0±0.3	1.34		1.40	
			A. semotus Fr.	5.8±0.7	3.6±0.4	1.63			
			A. xantholepis (Moell.) Moell.	5.6±0.7	4.0±0.2	1.39			
			[t] *A. lutosus* (Moell.) Moell.	5.1±0.4	3.9±0.2	1.28			
			[t] *A. diminutivus* Pk.	4.8±0.4	3.3±0.3	1.48			

Notes:

* the arithmetic mean of length and width of 100 spores of each species;

** the value of root-mean-square deviation in the case of each species

[t] the type of species was taken for processing

[R] the material collected and determined by H. Romagnesi was taken for the study (*A. radicatus* Vitt. ss. Romagn.), Sens (Yonne) Oct., 1938.

[B] the material collected and determined by G. Bohus was taken for the study

of M. MOSER (1967), the intrageneric taxa of the same rank (sections) are distinguished sometimes on the basis of the flesh colour during autooxidation (*Rubescentes*, *Flavescentes*), sometimes on the basis of carpophore habitus (*Minores*).

Table 2

Systems of the Genus Agaricus Fr. em. Karst.

KONRAD, P. — MAUBLANC, A. (1948):

Genus *Agaricus*

Section *Campestres* Konr. et Maubl. (1924) em.
(= *Rufescentes* J. Schaeff. et Moell., 1938)
Group *Campester*
Group *Silvaticus*
Section *Arvenses* Konr. et Maubl. (1924)
(= *Flaventes* J. Schaeff. et Moell.)
Group *Arvensis*
Group *Xanthodermus*
Group *Graciles*

PILÁT, A. (1951):

Genus *Agaricus*

Subgenus *Euagaricus* Pil.
Section *Rufescentes* J. Schaeff. et Moell.
Section *Sanguinolentae* J. Schaeff. et Moell.
Section *Flaventes* J. Schaeff. et Moell.
Subgenus *Melanophyllum* (Vel.) Pil.

MOELLER, F. H. (1950—1951):

Genus *Agaricus*

Section *Rubescentes* Moëll.
Group *Edulis*
Group *Silvatica*
Group *Vaporaria*
Group *Spissa*
Group *Campestris*
Section *Flavescentes* J. Schaeff. et Moell.
Subsection *Majores* Fr. p. p.
Group *Augusta*
Group *Arvensis*
Group *Xanthoderma*
Group *Macrospora*
Subsection *Minores* Fr.

SINGER, R. (1951):

Genus *Agaricus*

Section *Campestres* Konr. et Maubl. (1924) em.
Section *Sanguinolenti* J. Schaeff. et Moell.
Section *Arvenses* Konr. et Maubl.
Section *Xanthodermatei* Sing.

KÜHNER, R. — ROMAGNESI, H. (1953):

Genus *Psalliota*

Section *Rubescentes* ss. Moell.
Group *Bitorques*
Group *Rufescentes* J. Schaeff. et Moell.
Group *Sanguinolentae* J. Schaeff. et Moell.

Section *Flavescentes* ss. Moell.
Group *Augustae* Kühn. et Romagn.
Group *Silvicolae* Kühn. et Romagn.
Group *Xanthodermae* Sing.
Group *Minores* Fr.

HEINEMANN, P. (1956):

Genus *Agaricus*

Subgenus *Agaricus*
Section *Campestres* Konr. et Maubl.
Section *Sanguinolenti* J. Schaeff. et Moell.
Section *Arvenses* Konr. et Maubl.
Section *Xanthodermatei* Sing.
Section *Brunneopicti* Heinem.
Subgenus *Lanagaricus* Heinem.
Section *Olivacei* Heinem.
Section *Lanosi* Heinem.
Section *Trisulphurati* Heinem.
Subgenus *Conioagaricus* Heinem.
Section *Intermedii* Heinem.
Section *Pulverotecti* Heinem.
Section *Striati* Heinem.

MOSER, M. (1967):

Genus *Agaricus*

Section *Edules* ss. Moell.
Section *Rubescentes* ss. Moell.
Section *Flavescentes* ss. Moell.
Section *Minores* Fr.
Section *Xanthodermatei* Sing.

SINGER, R. (1975):

Genus *Agaricus*

Subgenus *Agaricus*
Section *Agaricus* (= *Campestres* Konr. et Maubl.,
= *Rufescentes* J. Schaeff. et Moell.)
Section *Sanguinolenti* (J. Schaeff. et Moell.) Sing.
Section *Arvenses* Konr. et Maubl.
(= *Flaventes* J. Schaeff. et Moell.)
Section *Xanthodermei* Sing.
Subgenus *Lanagaricus* Heinem.
Section *Olivacei* Heinem.
Section *Lanosi* Heinem.
Section *Lanagaricus* (= *Trisulphurati* Heinem.)
Subgenus *Conioagaricus* Heinem.
Section *Intermedii* Heinem.
Section *Pulverotecti* Heinem.
Section *Conioagaricus* (= *Striati* Heinem.)

WASSER, S. P. (1976):

Genus *Agaricus*

Subgenus *Agaricus*
Section *Agaricus*
Subsection *Rufescentes* (J. Schaeff. et Moell.) S. Wasser comb. n.
Series *Campestris*
Series *Vaporaria*
Series *Spissicaulis*
Series *Radicata*

Subsection *Sanguinolentae* (J. Schaeff. et Moell.) S. Wasser comb. n.
Series *Silvatica*
Series *Aestivalis*
Series *Lignicola*
Section *Duploannulatae* S. Wasser sect. n.
Subgenus *Flavoagaricus* S. Wasser subgen. n.
Section *Majores* Fr. p. p.
Subsection *Flavescentes* (Moell.) S. Wasser comb. n.
Series *Augusta*
Series *Arvensis*
Series *Macrospora*
Subsection *Xanthodermatae* (Sing.) S. Wasser comb. n.
Section *Minores* Fr. p. p.
Subgenus *Lanagaricus* Heinem.
Section *Olivacei* Heinem.
Section *Lanosi* Heinem.
Section *Trisulphurati* Heinem.
Subgenus *Conioagaricus* Heinem.
Section *Intermedii* Heinem.
Section *Pulverotecti* Heinem.
Section *Striati* Heinem.

As a result of the analysis of the morphological and anatomical, cultural, physiological and biochemical data and those of the biometric study on spores, a new system of the genus *Agaricus* is suggested (Table 2), involving four subgenera, ten sections, four subsections and ten series.[1]

In our system a complex of characters with the predominance of the colour character — the flesh colour under autooxidation which is constant in the genus *Agaricus* (turning to pink, red = subgenus *Agaricus*, turning to yellow = *Flavoagaricus*) — is assumed as a basis for distinguishing the subgenera. When distinguishing the sections in the subgenus *Agaricus*, the structure of the ring (simple, double or peronate) is taken as a basis, and in the subgenus *Flavoagaricus* — the habitus of the carpophores. A complex of characters which are assumed as a basis of distinguishing the intrageneric taxa of the same rank is strictly kept.

Key to the intrageneric taxa of the genus Agaricus[2]

1a. The flesh under autooxidation is light pink, pink, red, carmine red. Smell acidulous, Schäffer's reaction negative as a rule

subgenus **Agaricus** . . . 2

[1] Our system is based on the analysis of the species of the genus *Agaricus* from the Northern Hemisphere. The subgenera *Lanagaricus* and *Coniagaricus* (the species of which grow in the Southern Hemisphere) are accepted as a suggestion of P. HEINEMANN (1956) without change, because we had no possibility to study their types.

[2] The key is composed to determine the intrageneric taxa of the genus *Agaricus* of the Northern Hemisphere. The key to determine taxa of every rank in the Southern Hemisphere is given in the paper of P. HEINEMANN (1956).

1b. The flesh under autooxidation is yellow, light yellow, yellowish pink or only the foot of stem turns intensively bright chrome yellow. Smell almond or anise. Schäffer's reaction positive except the species of the subsection *Xantodermatae*)

subgenus **Flavoagaricus . . .** 4

2a. The ring is simple. Cystidia at the edges of the lamellae are of various form, from spheroid to clavate; spores ovoid-ellipsoid, ovoid

section **Agaricus . . .** 3

2b. The ring is double[3], peronate. Cystidia at the edges of the lamellae are narrow, spire-shaped, clavate; spores ovoid-spheroid.

section **Duploannulatae**

3a. The flesh under autooxidation turns to light pink, pink

subsection **Rubescentes**

3b. The flesh under autooxidation turns intensely red, carmine-red

subsection **Sanguinolentae**

4a. Species of middle and large sizes (pileus 6—25 cm in diameter). The ring is well developed, squamose below. Spores from middle to large sizes (to 12—13 μm long)

section **Majores**

4b. Species of small sizes (pileus 2—6 cm in diameter). The ring is weakly developed, often disappearing, naked below. Spores of small sizes (4—6 μm long)

section **Minores**

5a. The flesh under autooxidation turns yellow, light yellow, yellowish-pink; no smell of carboxylic acid. Schäffer's reaction positive

subsection **Flavescentes**

5b. The flesh under autooxidation turns bright chrome yellow only at the foot of the stem; with smell of carboxylic acid. Schäffer's reaction negative

subsection **Xanthodermatae**

To establish the interrelations within the genus, subgenera, sections, subsections and series it is necessary to study and analyze the characters indicating the relative antiquity or youth of the species. The characters of area, quantity of the species, shape of spores, type of development, structure of

[3] The double ring is a ring peculiar, for example, to *A. bitorquis*. In our system all species with the double ring belong to the section *Duploannulatae*. The rest of the species have a simple ring.

lamella trama, character of intraspecific variability, spore print colour, presence or absence of spore fibulas, sex differentiation are such characters for agarics (SINGER, 1962). Having grouped morphologically the similar species and then taken into account the similarity of K_m, and finally analyzed the characters indicating the relative youth or antiquity of the species it became possible to judge, with a great percentage of trustworthiness, the level of evolutionary development of the species or groups of species, and the phylogenetical relations within the genus. The most ancient within the limits of the genus proved to be the section *Duploannulatae* of the subgenus *Agaricus* (K_m for the section is 1.28), followed by the sections *Minores*, subsections *Flavescentes*, *Xanthodermatae* (Table 1).

The analysis of the sections and subsections of the genus shows that within the limits of each of them there are species with both low and high K_m, *i.e.* the ancient species (*A. bernardii*, *A. bitorquis*, *A. velenovskyi*) and the young ones (*A. annae*, *A. campestris*, *A. langei*, *A. xanthodermus*).

As the value of K_m and other parameters are very similar in certain species of different sections and subsections, one may safely assume simultaneous parallel evolutions within the sections. The representations concerning the simultaneous parallel evolution of the species within the sections as well as the establishments of the most ancient species in each of them and the relationship between these will be a reliable basis when composing the evolutionary relations in the genus *Agaricus*.

REFERENCES

DENNIS, R. W. G.—ORTON, P. D.—HORA, F. B. (1960): New check list of British Agarics and Boleti. Suppl. Trans. Brit. Mycol. Soc. **43,** 1—225.

DUNCAN, E. G.—GALBRAITH, N. H. (1973): Variation in the dimensions of basidiospores during the discharge period. Trans. Brit. Mycol. Soc. **60,** 463—470.

Гарибова, Л. В.—Сафрай, А. И. (1972): Оценка некоторых таксономических признаков видов рода Agaricus. — Микология и фитопатология, 5, 6, 440—443.

Гарибова, Л. В.—Мокеева, В. Л. (1974): О различнях методах и последовательности их применения в систематике/на примере рода Agaricus Fr. — Микдогия и фитопатология, 8, 6, 533—537.

HEINEMANN, P. (1956): Champignons récoltés au Congo Belge par Madame M. Goossens-Fontana. II. Agaricus Fries ss. Bull. Jard. Bot. l'État. Brux. **26,** 1—128.

KONRAD, P.—MAUBLANC, A. (1948): Les Agaricales. Encyclopédie Mycologique **14,** Paris, 1—469.

Меркурьева, Е. К. (1963): Основы биометрии. — Москва.

MOELLER, F. H. (1950, 1951): Danish Psalliota species I—II. Friesia **4,** 1—60, 135—220.

MOSER, M. (1967): Die Röhrlinge und Blätterpilze (Agaricales). In Gams, H.: Kleine Kryptogamenflora, II **b/2.** 3. Aufl. Stuttgart, 1—443.

PILÁT, A. (1951): České druhy žampionů (Agaricus). The Bohemian species of the genus Agaricus. Sborník Narodního Musea v Praze, **7, B 1,** 1—142.

Райтвиир, А. Г. (1973): О применении математических методов в систематике грибов. — Тезисы докладов у сьезда ВБО, Киев, 345—347.

SINGER, R. (1951): The Agaricales (Mushrooms). In modern taxonomy. Lilloa, **22,** 1—832.

SINGER, R. (1962): The Agaricales in modern taxonomy. Weinheim, 1—915. 2. ed.

SINGER, R. (1975): The Agaricales in modern taxonomy. Vaduz, 1—912. 3. ed.

Зингер, Р. (1950): Naucoria Fr. и близкие роды в СССР. Споровые растения. — М.-Л., 6, 402—499.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (1—2), pp. 259—268 (1976)

RECENSIONES

Ecological studies in Japanese grasslands with special reference to the IBP area. Productivity of terrestrial communities. JIBP Synthesis. Vol. 13. Edited by M. NUMATA. Univ. of Tokyo Press, 1975.

The book is a summarizing volume of the Japanese IBP grassland examinations, under the editorship of M. NUMATA. The volume is divided into 10 chapters, the number of articles varies according to chapters. The various articles have been written by one to four authors, the number of co-workers is altogether 43.

In Chapter I, NUMATA deals with the preceding events; the formation of the grassland ecology group (1961), then the planning and surveying of the work carried out in the first and second phases of the IBP. Grassland investigations were carried out in *Miscanthus sinensis* and *Zoysia japonica* types as well as in dwarf bamboo *(Sasa)* and sown pastures. The main part of the examinations was carried out in the IBP sampling area of Kawatabi, with four additional sampling areas.

Chapter III, dealing with the classification, structure and succession of the grassland vegetation, the articles discussing the changes in succession and structure as well as the relations between succession and productivity in *Miscanthus* associations are very interesting. The investigations of viable buried seed population are worthy of special attention. Chapter IV deals with the abiotic factors influencing the biological production. In the first article of this Chapter, NUMATA and MITSUDERA discuss the environmental factors affecting the growth and production of *Miscanthus* grasslands. In the other articles, the authors describe the climate, soil, relationship between soil and plant, and the effect of soil on the biological production. The authors of Chapter V treat the question of measuring and comparing the primary productivity of semi-natural grasslands. Thus they discuss the production of aboveground and underground organs in *Miscanthus* association and the primary production of the semi-natural pasture, where *Zoysia* is dominant as well as of *Arundinario-Miscanthetum*. The net production and standing crop in three sampling areas of *Miscanthus sinensis*-type associations are surveyed in a separate compilation. In Chapter VI the seasonal and annual changes in the biomass and litter are summarized and also the results of the chemical analysis of the underground and aboveground organs of *Miscanthus* and *Sasa palmata* are given. In Chapter VII, the authors write about the influence of biotic factors on grasslands. They studied the effect of cattle grazing on vegetation and on the morphology of *Sasa* in pastures where *Sasa* dominates. The authors studied the possibility of eliminating the harmful effects of overgrazing. An interesting study is given in this Chapter on the comparison and economic importance of productivities in the semi-natural *Miscanthus* pasture and that improved with a mixture of orchardgrass and ladino clover. Another extensive study deals with the causes of deterioration of sown grasslands as well as growth in weeds. The summary of examinations related to the amount of grazing consumption of herbivorous insects is interesting. Chapter VIII contains the studies on the decomposition of litter. It is also here that the summary of microbiological examinations, the role of microfungi in the decomposition processes, the investigation of *Miscanthus* and *Sasa* litter decomposition in semi-natural conditions in five years, the decomposition of meso- and macrofauna litter, and the soil respiration of *Miscanthus* grasslands are to be found.

While the former chapters were in their majority of a botanical subject, Chapter IX is faunistical. After reviewing the arthropod fauna of the sampling area, the authors review

the productivity of some grasshopper species. Papers describing the extension and distribution of populations of nesting birds and small mammals are also included. In the last chapter two models are presented. One describes the changes and dynamics of the biomass in *Miscanthus* and *Zoysia* plant associations in grazed conditions, and the other in non-grazed ones.

A good survey of the work and results of the JIBP-PT section is provided in the volume. A further aid to comprehension may be the data from the literature given at the end of the various chapters. They mainly contain Japanese references.

I. PRÉCSÉNYI

Ресурсы Биосферы (Итоги советских исследований по Международной Биологической Программе) Был. 1 1975. 286 ст. 1 р 97 к. Издательство Наука, Ленинград

(Resources of the biosphere. Synthesis of the soviet studies for the International Biological Programme) Volume 1. 1975. 286 pp. 97 k. "Nauka" Leningrad.

Between 10 to 12 December, 1974, the Soviet National IBP Committee organized a symposium summarizing the results on the main sections of the Soviet national IBP programme.

The first volume of papers presented on the symposium was published in 1975 (Nauka, Leningrad), with a foreword by professor B. E. BYCHOVSKY and by professor O. N. BAUER, chairman of the Soviet National IBP Committee.

The soviet biologists participate in the International Biological Programme since 1964. The Soviet National IBP Committee organized more than 250 scientific institutions of various subordination, made regular communications with the SCIBP and with the international sectional committees.

The studies have been performed according to the "Soviet biological national programme" (Publishing House "Nauka" 1969). Productivity of terrestrial, fresh-water and marine ecosystems, theoretical bases of terrestrial conservation, biological control of the main pests, plant gene pools were studied.

The present volume comprises the concluding articles on the sections "Productivity of terrestrial communities" and "Production processes".

V. F. SHAMURIN, V. D. ALEKSANDROVA, B. A. TIKHOMIROV: Primary production of tundra communities

The primary production of plant communities of polar desert, tundra, and forest-tundra is reviewed, with special reference to the published data. The data include the structure and stock of the aboveground and underground phytomass in communities of the watershed plains and mountains in various localities of tundra in the USSR. The seasonal changes in the aboveground phytomass, the values of its annual increase and litter-fall are included for some communities.

P. L. GORCHAKOVSKY, N. J. ANDREYASHKINA: Studies on primary production of communities at the station "Harp" (forest-tundra)

At the forest-tundra station "Harp" phytomass, annual production of aboveground parts of vascular plants, and the rate of decomposition were studied in 10 types of plant communities (6 tundra, 2 meadows, 1 swamp, 1 open woodland community).

Techniques of determination of annual production of hypoarctic shrubs and shrublets have been developed.

G. B. GORTINSKY, A. A. MOLCHANOV, M. A. ABRASHKO, A. D. VAKUROV, I. I. GUSEV, I. V. ZABOEVA, YU. N. NESHATAEV, V. V. SMIRNOV, A. I. UTKIN: Productivity of forests in the European part of the USSR

The biological productivity of forests of various botanico-geographical subzones of the USSR is reviewed. The productivity of spruce forests increases from the northern taiga to southern taiga, and within subzones — in the south-west direction as the continental properties of climate decrease. Maximum values (460 t/ha) are known for *Larix* stands, the spruce stands in the same conditions reaching up to 350 t/ha of dry mass. The highest values of annual production (more than 10 t/ha) are noted for the spruce forests in Estonia, the Moscow district, and for *Quercus* stands in the Voronezh Reservation. Metabolism is essentially different depending on tree species and on the chemical properties of the soil.

L. K. POZDNYAKOV: Productivity of forests in Siberia

Data are published on the biological productivity of forests in Siberia obtained during th last five years by the SUKACHEV Institute of Forests and Timber, Siberian Branch, Ac. Sci. USSR. Phytomass of the ripening and ripe forests increases from 60 t/ha to 250 as the continental properties of climate decrease. As a rule the productivity of *Larix* stands is higher than that of pine stands under the analogous conditions in the middle taiga zone. As the continental properties of climate increase, the ratio of leaf weight to the total aboveground phytomass increases. The masses of crowns of different species under different conditions are very similar and depend only on the size of trunks. Chemical composition in stands growing under the same climatic conditions may considerably vary and it depends on soil.

N. I. BAZILEVICH (ed): Productivity of steppe, meadow and swamp biogeocoenoses of the forest steppe

The results of studies of 12 grass biogeocoenoses in the subzone of the meadow steppe in the European part (Kursk and Tambov stations) and in the Asiatic part of the USSR are reviewed (Asiatic part — Karachi station). A complex characteristic of environment, vegetation, fauna, microorganisms is produced for each biogeocoenosis. Phytomass stock, annual production, loss of matter are described in their seasonal and annual changes, as well as the mineralization of organic matter. The correlations between the annual production and hydrothermal regime are pointed out. The significance of the heterotrophic organisms (their various trophic groups) in the mineralization of the litterfall is revealed. A functional model (blocks and flows are outlined) of turnover processes and a mathematical model of water turnover processes are constructed for the grass biogeocoenoses.

N. P. GURICHEVA, O. M. DEMINA, G. J. KOZLOVA, L. I. NOMOKONOV, K. D. STEPANOVA: Productivity of meadow communities

Meadow communities (associations of perennial grass-like mesophytes) are autotrophic components of meadow biogeocoenoses with a complex space-time structure. Most widely meadows are distributed in the forest and steppe zones having temperate climate. According to position, meadows are continental, flood-plain, and mountain meadows.

The PT IBP programme included the study of 41 types of meadows at 12 stations on the plains of the USSR. More complex studies have been made at the station "Otradnoe" (continental meadow of Karelia) and at the station "Karachi", Novosibirsk district (lake flood-plain meadows). The total phytomass stock of the continental meadows varies from 15 to 60 t/ha, with a mean ratio of aboveground to underground phytomass 1 : 1—1 : 6 (12). The corresponding figures for flood-plain meadows are 17—75 t/ha, and 196 (9). Fertilization can increase the productivity of meadows 1.5—3 times.

L. E. RODIN (ed): Productivity of desert communities

The results of IBP studies, made at 5 stations in the USSR (sand desert M. Barsuky; sand desert Taukum; gypsum plain in Kysylkum; Central Karakum, Karrykul; South-Eastern Karakum, Repetek reservation), and at one station in the Mongolian People's Republic (Gobi) are described. These stations are distributed throughout the various subzones of the desert zone in Asia. The physico-geographic characteristics of these stations are pointed out; 15 communities (natural and anthropogenic) have been studied, formed by trees *(Ammodendron argenteum, Haloxylon ammodendron)*, shrubs *(Ephedra lomatolepis)*, semishrubs (*Calligonum* sp.), semi-shrublets *(Artemisia, Salsola, Anabasis)*, and grasses *(Agropyron fragile)*. The data are given on phytomass, annual increase (production), litterfall for the aboveground and underground parts of the communities. Water balance, photosynthesis, and chemical composition are discussed for the main edificators. The features of the biological turnover of the ash elements and of nitrogen, the calorific value, are considered. The pasture value, stock of fuel wood are evaluated, the ways of rational use are pointed out.

K. A. MALINOVSKY (ed): Productivity of mountain communities in the USSR

The results of IBP studies in some mountaineous regions of the USSR (Caucasus, Carpathian mountains, Tien Shan, Pamirs) are described. Various communities are analyzed, including mountain forests (of *Picea abies, Malus siversii*, and artificially planted *Pinus silvestris*), subalpine shrubs *(Pinus mugo, Alnus viridis)*, various mountain meadows (*Nardeta, Festuceta, Deschampsieta, Cariceta*, etc.), mountain steppe communities (*Stipeta, Dichantieta*, etc.), high-mountain steppe communities *(Hordeeta)*, cushions high-mountain desert communities *(Ceratoideta)*, cryophyle *(Oxitropideta)*, etc.

The main physico-geographic characteristics of communities, phytomass, annual production, litterfall are indicated for the aboveground and underground parts of the communities.

The features of biological turnover of ash elements and of nitrogen the calorific value, are discussed.

L. N. DOBRINSKY: Optimum density and optimum structure of animal populations

Numbers and biomass of animals, significant commercially or biologically are measured in various parts of their areas. The results of soviet ecologists on the biomass of wild animals in various zones, on population structure, and on population dynamics are discussed, as well as some results of studies in field stations.

M. S. GHILAROV, YU. I. CHERNOV: Soil invertebrates in communities of the temperate zone

A synopsis of results of the quantitative pedo-zoological studies in the USSR, made within the IBP program, is published. Numbers and mass for various groups of soil fauna in the main zonal communities from tundra to desert are included. The total quantitative indices of the soil fauna are correlated to those of the plant cover. Various forms and scale or biogeocoenotic activities of soil animals are demonstrated, based on the community structure and on data of experimental researches.

T. V. ARISTOVSKAYA: Numbers, biomass and productivity of soil bacteria

Quantitative characteristics of bacteria were studied for soils in various geographic zones. In every location, short-time fluctuations of numbers, biomass and productivity are revealed, the sharpest in soils of the far North. The rate of propagation and death of bacteria in soils depend on soil and climate peculiarities and on season. The production process is not continuous and the most intensive formation and disappearance of bacterial biomass takes place in certain months or weeks during the active season.

E. N. MISHUSTIN, T. A. KALININSKAYA, N. M. SHEMAKHANOVA: Assimilation of molecular nitrogen by free-living and symbiotic microorganisms

The results of studies in biological fixation of nitrogen are summarized, performed by the participants of the IBP in the USSR in 1966—1972. The following sections are discussed: biochemistry of biological fixation of nitrogen, symbiotic fixation of nitrogen by Leguminosae and non-Leguminosae, free-living N-fixators, *Cyanophyceae*, symbiotic and non-symbiotic N-fixation in nitrogen balance of soil.

To sum up, it can be stated that in this synthesis the phytomass stock, annual production, processes of mineralization and turnover in various types of biogeocoenoses — tundra, forests, grasslands, deserts — are analyzed.

Informations are given on the biomass of wild animals and soil bacteria in various zones as well as on the results of the first interdisciplinary studies of the Soviet ecologists.

The present review of the most important results of the Soviet scientists in the frame of the IBP may be recommended for all those interested in ecology, productivity and nature conservation.

E. LÁNG

DARIMONT, F.: Recherches mycosociologiques dans les forêts de Haute Belgique I—II. Institut Royal des Sciences Naturelles de Belgique. Mémoire No. 170.—1973, pp. 1—220, with a coloured map, 34 colour plates and 30 tables; price 4000 francs.

It is a great pity that the excellent work of FREDI DARIMONT could not be published after its completion in 1952, soon after the early demise of its author. Therefore, regrettably, it could not be considered in mycocoenological researches (not even in the Belgian ones) that have since then been carried on extensively. A study of the work would have been especially useful for the authors of the summarizing works that have been published since that time.

Even so, it is fortuitous that in the organization of the Institut Royal des Sciences Naturelles de Belgique, with the financial support of the Institute and of others, the work could be published in two volumes, in a representative edition, yet only as a posthumus work. The costs of the publication were considerably increased by the 34 colour plates, and the large-size tables enclosed in a separate volume.

The author carried out the surveys in 18 forests relegable to 6 associations and forest-types, as follows:

Quercetum sessiliflorae medioeuropaeum:

45 areas observed, 2 areas analyzed mycocoenologically

Fagetum boreoatlanticum: 6 — 3

Querceto-Carpinetum medioeuropaeum primuletosum veris: 28 — 3
Querceto-Lithospermetum: 3 — 1
Acereto-Fraxinetum: 18 — 4
Querceto-Carpinetum medioeuropaeum caricetosum glaucae: 9 — 1

In ecoclimatically uniform areas, the physiognomically homogeneous fungus communities were studied within their natural boundaries instead of observing constant squares.

The basis of the author's view is that fungi, besides the two great groups of plants and animals, should be considered a separate phylum.

Within the areas of forest associations, and forest types, forest "mycotopes" are separated. Such are, for example, the surface of the soil with humus content, the surface of a fallen tree trunk, etc. The mycotopes are populated with fungus communities (Mycetation), divided by the author into classes. With regard to the mycocoenoses of the surface of the forest soil, such a class is the *Cortinario-Boletacea.* Within the classes, orders are distinguished, and within these further units separated. For example:

Class: *Cortinario-Boletacea*
Order I: *Boleto-Amanitecia*
mycocoenoses of forests on silicate soil
Order II: *Cortinario-Inocebia*
mycocoenoses of calcicolous forests
Order III: *Galactinio-Laccariecia tortilis*
mycocoenoses of clay soils laid bare

The author has analyed the species characteristic of the various units. In order to characterize and compare the fungus communities, he studied their frequency, constance, sociability and fidelity interpreting them on the basis of his own conception.

In the synoecological characterization of the various fungus communities, DARIMONT mentions conditions different from those observed in Hungary. So, for example, he characterizes *Morchello-Cortinariecium* as follows: "Calcicole, basophile (pH 7—7.3), mesophile, termophile" and under the "Characteristiques exclusives" enumerates e.g. *Caloporus (Polyporus) cristatus* which grows in Hungary exclusively on soils with pH values 3.5—5. Further he writes from *Boletecium regii* sociomycium: "Calcicole, basophile (pH 7—7.5), xerophile, termophile." And as regards *Boletus regius* — the species giving the name of the unit — it grows in *Luzulo-Quercetum* and in the more acidic stands of *Quercetum petraeae-cerris* in Hungary.

The cause of differences may probably be found in the fact that, owing to the stronger bleaching, the mosaicism of the biotopes is increased in Belgium where precipitation is more frequent. It seems also probable that DARIMONT did not measure the pH values of the soil in habitat spots but took into consideration rather the reaction character of the basic rock. Examples of such phenomena are found also in Hungary (Bükk mountains); there are areas with limestone as the basic rock, but where the overlying thicker soil cover became locally acidic, resulting in the appearance of species otherwise characteristic of soils on an acidic rock substrate.

G. BOHUS

C. L. HITCHCOCK—A. CRONQUIST: Flora of the Pacific Northwest. An illustrated Manual. Univ. Washington Press, Seattle—London, 1973. XIX 730 pp. £ 9.—

The manual of vascular plants inhabiting the Pacific Northwest (Washington, the mountain regions of North Oregon, North Idaho and Montana) is a concise version of the 5-volume compilation published in the course of one and a half decades (1955—1969). Now it is a one-volume work in a different form. The flora approximately 3—4 thousand species of the extensive region in the USA mentioned above — could be presented in one volume by unusual conciseness only and in the form of keys with drawings. It must be emphasized right at the beginning that this impressive manual of large form is a masterpiece of conciseness: almost every mm^2 of the type-area has been perfectly used, and yet carried out without detriment to the comprehensibility. The dichotomic keys, which for reasons of shortness work with more than a hundred morphological and geographical abbreviations in addition to the conventional signs, make possible the identification of all species (and even many of the varieties) of this region so rich in flora. Parallel with the keys the habitat picture or section drawings of most of the species, scaled down strongly, are to be found on the left margin of the pages.

After the short introduction and morphological dictionary, the manual offers two types of key for the identification of the families, then the descriptive part follows, making up

95% of the book. Dicotyledonous families follow each other in ENGLER's system, while the monocotyledonous families that of CRONQUIST. On the other hand, the various genera are placed in the alphabetic order within the family, which is unusual for us. In the genera, the concise morphological description and generic name etymology are given then the keys to species (sometimes to subspecies or to varieties). After the morphological description, the habitat and range of all taxa are given, together with their more important synonyms. (The latter are without authors' names and not extensive; concerning the details, they refer to the five-volume text-book.) It is a useful help that occasionally there are even two types of key (for example, in *Umbelliferae* and *Compositae*, for both the vegetative and the reproductive phases; in *Astragalus*, a genus rich in species, on the basis of both the blossoming and fruiting stages). — The great majority of the families have been elaborated by HITCHCOCK, while the smaller part by CRONQUIST; most of the pictures are by J. R. JANISH. Concerning the pictures it should be noted that they are mostly not habitat pictures but mainly section drawings necessary for identification. In the interests of conciseness, the extent of neither their minimization nor their magnification is indicated. The section-drawings — owing to their connecting lines being dropped — do not always permit an unambiguous identification and the tiny pictures can only be used with the aid of a magnifying glass.

The very accurate and thorough lay-out and the excellent quality of paper contribute to a great extent to the fact that this floristic manual of a very thorough and extremely concise composition and illustration is an indispensable handbook for those who wish to know the flora of the enormous area.

SZ. PRISZTER

С. Петров: Определител на мъховете в България (S. PETROV: Key to the identification of bryophytes in Bulgaria). 1975, 536 pp, 124 plates, Izd. Akad. Nauk., Sofia

An important summarizing work in bryology has been published by S. PETROV. It contains the whole bryophyte flora of Bulgaria. Its knowledge is of great importance for European florists and moss geographers. Before this publication the relevant data have been known from various scientific papers only. At the same time, this work is an addition to a great extent also to the literature on the bryophyte flora of South Europe.

The flora of Bulgaria contains 670 bryophyte species; among these, 167 are liverwort, 26 *Sphagnum* and 476 moss species.

The work consists of two parts: general part and taxominocal.

The general part deals with the technique of moss collecting; the requirements of establishing a herbarium; the instructions on the identification of moss species as well as on the use of keys; the preparation of liverworts, *Sphagnum* and mosses for their identification. This part deals with the explanation of fundamental terms related to the organic construction of mosses; excellent drawings illustrate them and facilitate the use of keys.

The taxonomical part contains the keys to bryophytes inhabiting Bulgaria. The main taxonomical groups (thalloid liverworts, leafy liverworts, Sphagnums, mosses) are divided on the basis of the characteristic external properties of the gametophyton. The description follows with keys to genera in liverworts, then keys to species of each of the various genera. Owing to their great number the genera of mosses are divided into 12 main character groups; within these main groups, the various genera are separated by keys. Within the genera, species keys are elaborated. Within Sphagnums (as there exists only one genus,) the species keys are elaborated. Together with the keys in all three groups also the short, concise, illustrative description of the genera is provided. At the end of the description of species there are remarks related to the habitat.

In order to facilitate the identification of the bryophyte species, drawings of good quality are given. They emphasize the most remarkable characteristics of the various species and may be useful also for researchers — in the identification of the various moss species — who do not know the Bulgarian language. The book is completed by a list of references, a detailed table of contents, and a Bulgarian and Latin language index of moss names.

The handbook is in Bulgarian, for it has primarily been compiled in order to facilitate the work of Bulgarian bryologists. It is difficult for foreign researchers to use it, but the Latin language species list and the very usable drawings of the good lay-out make it possible for all bryologists to use it at least partly. The handbook offers a great help in the identification of many South-European moss and liverwort species.

S. ORBÁN

Д. К. Зеров, Л. Я. Партика: Мохоподібні українських карпат (D. K. ZEROV, L. A, PARTIKA: The mosses of the Ukrainian Carpathians). 1975. 230 pp, 13 maps, Naukova Dumka. Kiev

The authors processed the data on the bryophyte flora of the Ukrainian part of the NE Carpathians. This region, owing to the numerous interesting bryophyte species, is one of the most explored regions of the Carpathians. The first data on the mosses of this area were published in 1847, thus, the results of more than a hundred years' bryological research work are summarized in the book.

The Ukrainian Carpathians are of a great variation both geologically and geomorphologically, therefore its bryophyte flora is also very rich. It contains 623 bryophyte species, 2 of which belong in the *Anthocerotopsida*, 163 in the *Hepaticopsida* and 488 in the *Bryopsida* (26 in the *Sphagnum* and 462 in the moss) classes.

The distribution of the species according to floristic elements also confirms the plant geographical importance and the manifoldness of the bryophyte vegetation of the region. The distribution of the bryophyte species according to area is as follows: 77 arcto-alpine, 63 boreo-arctic, 194 boreal, 21 boreo-nemoral, 166 nemoral, 22 nemoral-Pontic, 30 Mediterranean-nemoral, 1 nemoral-Mediterraneo-Pontic, 1 Mediterranean, 47 holarctic and 24 elements of non-determined area.

The most interesting species, new for the whole area or very rare in the whole Carpathians, are as follows: *Clevea spathysii*, *Metzgeria fruticulosa*, *Metzgeria hamata*, *Pallavicina lyellii*, *Fossombronia pusilla*, *Cephalozia loitlesbergeri*, *Calypogeia sphagnicola*, *Gymnomitrium apiculatum*, *Gymnomitrium coralloides*, *Scapania subalpina*, *Frullania jackii*, *Sphagnum balticum*, *Sphagnum papillosum*, *Fissidens rufulus*, *Fissidens marginatulus*, *Trichostomum viridulum*, *Conscinodon cribrosus*, *Orthotrichum leucomitrium*, *Myurella tenerrima*.

The work consists of four main parts. In the first part the authors review in detail the history of the bryophyte research related to the area. In the second part (constituting three-quarters of the book), the species occurring in the region are reported in their taxonomical order, together with their habitats; all the earlier data of literature and herbaria are also processed. In the third part, the vertical distribution of mosses and liverworts is analyzed. Three vegetation belts are examined, *viz.* beech, fir and subalpine-alpine belts (as the true alpine is only of insignificant magnitude), and within the forest parts the rocky and marshy sites are examined separately. The characteristic moss associations of all vegetation belts are enumerated. The last chapter provides the plant-geographical analysis of the mosses and liverworts in the Ukrainian Carpathians, giving thus valuable pieces of information on the bryophytes of the region according to groups of floral elements. The most interesting in the flora of the region are the arctoalpine, the boreal-arctic and the Mediterranean elements; boreal and nemoral elements are dominant.

At the end of the book a list of references is to be found.

This work elaborating the flora of a relatively small region which, however, is very rich and complex with respect to the number of species and floral elements — will be of great use to the moss florists and geographers who study the moss flora of the Carpathians, but it may provide interesting data and novel information to all florists of Europe and of other continents.

S. ORBÁN

Z. I. ASAUL: Identification book of the Euglenophyta algae of the Ukrainian Soviet Socialistic Republic. Kiev, 1975. 1—408 p. 3.80 rubels.

The investigations on the *Euglenophyta* organisms are very important both from theoretic and practic viewpoints, since they promote a better understanding of the phylogenism and the organisms of the lambda$_1$ level: they are important nutritive materials for higher aquatic organisms, like fish. Up-to-date identification books mean a great support to further researches, too, and they are likewise indispensable in higher education; similarly, they have such character from the view-point of the hydrobiologists and fishery specialists, working in the praxis. Therefore the work of the author, a well-known figure in this field of science is welcomed with much pleasure.

Hydrobiologists and algologists of the Ukraine published plenty of data concerning *Euglenophyta* originating from various biotopes. Consequently they have accumulated a great deal of systematical, morphological and ecological data especially related to the colourless species. These have been summarized by the author in a very lucid manner, 502 species are reported from the territory of the Ukraine of which 177 are colourless; most of the species

appear here for the first time. Author has wholly surveyed the special literature until 1972. The general part comprises 29 pages where the reader is informed about morphology, biology, ecology, systematics and phylogenetic relations. The special part, characterizing briefly the *Euglenales* and *Peranematales*, gives diagnoses of the families and genera, clear identification keys, amply illustrated with good figures. The final number of figures is 249, but each figure is built up of many partial figures; accordingly, the real number of illustrations runs into several thousands! This fact alone makes the work valuable; though the keys are in Ukrainian the many figures highly facilitate their use.

The voluminous work of Z. I. ASAUL appeared in the series of the Ukrainian and USSR Identification Books, well-known and highly esteemed everywhere. We are much awaiting the further volumes.

T. HORTOBÁGYI

PANKOW, H.: Algenflora der Ostsee. II: Plankton (493 p. 880 figures, 26 tables with 175 photos. Jena, VEB Gustav Fischer 1976. Cloth. Price abroad: 71.— M.)

H. PANKOW, Professor of the Rostock University, in collaboration with Volkbert KELL and Brunhilde MARTENS, has accomplished a work, honourable in all respects when he, by making use of 778 special papers and his own investigations, summarized the alga-planktonic organisms of the Baltic Sea together with diatoms *(Diatomaphyceae)* of the benthos, since the latter very often are present in the plankton. This identification book with critical remarks is indispensable for specialists engaged in fresh water research. The layout of the book is similar to the previous excellent PASCHER books.

After the introduction and list of contents, the work is divided into several chapters. First a brief review of the adopted halobic system is given followed by an identification key of the algae found in the Baltic Sea. The 19 genera of *Cyanophyta* are treated on 25 pages. Concerning *Chrysophyta*, 13 genera from *Chrysophyceae*, 3 genera from *Xanthophyceae* and 1 genus from *Craspedophyceae* are discussed on 13 pages. The bulk of the identification book is occupied by diatoms *(Diatomaphyceae-Bacillariophyceae)* in a total of 263 pages. The organisms of *Pyrrhophyta* take up 34 pages, the green algae *(Chlorophyta)* 30 pages and finally *Euglenophyta* a mere 5 pages.

The book gives very good and detailed identification keys. The figures and photos are fine, they highly facilitate precise identification. We should comment especially on the very precise literary references and the list of the most important synonyms.

The book is completed with a detailed Bibliography, Corrections and Addenda, related to the "Algenflora der Ostsee I. Benthos" (8 pages), and an Index.

The well-edited work with a fine cover will most certainly be welcomed by hydrobiologists engaged both in theoretical and practical work.

T. HORTOBÁGYI

THOMAS, E. and DAVEY, M. R.: From single cells to plants. Wykeham Publications Ltd., London and Winchester. 1975. pp. 172; 73 illustrations. £ 2.50

The book is a recent excellent contribution to the literature on plant tissue culture. All what is known on this subject today is briefly included. The authors' aim was to provide it as a supplement to the knowledge of those who work in plant physiology. However, the book is much more than that. It discusses recent results, presents problems and future perspectives of plant tissue culture. After a short — we should say obligatory — historical survey and an equally necessary review of technical methods and basic materials, the book contains the following chapters. In the chapter entitled "The Culture of Plant Organs" all possible cultures that can be induced from the various plant organs (root, stem, leaf, shoot, flower, ovaries, anthers and embryo) are surveyed. Chapter 4 deals with the cultures of plant cells, including callus cultures, with cell suspension and single cell cultures, and also with the microscopic and ultrastructural construction of cells. Chapter 5 discusses the isolation and behaviour of higher plant protoplasts. Besides the methods of isolation, also the properties, development, physiological and practical applications of protoplasts are touched upon. Chapter 6, "The Morphogenesis of Cell Cultures", calls attention — with regard to plant breeding and propagation — on the way of the formation of the various organs from cells, on factors controlling morphogenesis, and on the applications in practice of the morphogenetic potentials of the

cells and tissues cultivated. Chapter 7 deals with the cultivation of haploid reproductive cells. The main parts of the chapter treat the topic of microspore formation, isolation, cultivation as well as the embryogenesis and organogenesis of microspores and their practical application in plant breeding. The last chapter analyzes, as future problems in this field of science, the generality of cell totipotency, the cytological instability of the cultivated cells, the possibility of modification and hybridization in plant cells, and also the expectable practical results of all these. The Appendix also contains methodical schedules besides the basal culture media. As an aid to further understanding, the book has been provided with a taxonomic index, a subject index and a substantial list of references. — This work summarizes the topic of plant tissue culture fairly well, briefly and demonstratively. In the massive information flow of today, works of this character assist in the most important orientation. Praise is due to the authors for this well-balanced work extending to every important detail and still remaining within moderate limits. The lay-out of the book is also fine, it praises the Publishers. The work will be of great use for both those who are at the beginning of orientation in this topic and those who have already acquired familiarity with it.

M. MARÓTI

WIESSNER, W.: Bioenergetik bei Pflanzen. (Bausteine der modernen Physiologie.) Jena, VEB Gustav Fischer 1975. 31.— M.

One of the most modern and important range of topics in plant physiology is the bioenergetics of plants. Professor WIESSNER's book gives information on this branch of science, with the aid of 55 figures, 44 demonstrating sketches and 22 tables, on 224 pages. Concerning bioenergetics, naturally it is mainly photosynthesis and plant respiration (that is, the fundamental life processes) which are dealt with. Fine-constructions or organellums producing the cytological scene of the processes are discussed to the extent of necessary details. The required knowledge related to the compounds participating in photosynthesis and respiration is summarized, then based on that from plant physiological, biophysical and biochemical viewpoints a detailed account of the processes, follows on molecular and even submolecular levels. The effect of outside factors and also of adjustability are taken into consideration to a far-reaching extent, in accordance with the leading principle that the organisms and the environment should be observed in their interdependence. The author avoids or only touches the ecologico-physiological connections known since long, and he pays greater attention to problems which have hitherto been pushed into the background; for example, on the partial pressure of oxygen effecting photosynthesis. Similarly, the question of so-called photo-respiration has come to the fore.

In agreement with the title of the book, the discussion of energetical problems is mostly emphasized, among these there occur, for example, electronic migration, energy transformation, and the storage of energy. The regulation of the processes (their co-ordination) is also one of the main thoughts in the book, indicating that Professor WIESSNER wishes to show the reader the plant organism as a unified system.

The style of the book is good and plain, therefore intelligible also to those who are trained in the German language only to a smaller extent. Besides specialists in biology, also students from the field of higher education may be advised to use this excellent work on a special subject.

V. FRENYÓ

HOPE, A. B. and WALKER, N. A.: The Physiology of Giant Algal Cells. Cambridge University Press, London—New York, 1975 (201 + XIII pages, 51 figures, 15 tables and 7 plates).

Biologists and physiologists have often profited from the survival of animals and plants which have cells of more than ordinary size. The giant cells of certain algae are of especial value as experimental material for the investigation of biological problems. Giant algal cells appear in literature with CORTI (1774, 1776), who observed and reported protoplasm existed as a concept. Long before YOUNG (1936) drew attention to the squid giant axon, physiologists had found *Valonia* and *Nitella* and had begun work on many of the problems discussed in this book.

The book consists of 12 chapters (pp. 1—175), abbreviations (I—XIII), appendixes (177—180) and references (181—197).

Chapter 1 sums up the taxonomy, the ultrastructure, culture and cell operations of giant algal cells. Chapter 2 gives a very comprehensive historical background of early plant algal physiology and puts recent work in perspective.

In Chapter 3 the authors consider water relations; they touch upon the osmotic potential of vacuolar sap, the transcellular osmosis, the osmotic flow during perfusion and the self diffusion of water.

Chapter 4 discusses the permeability to nonelectrolytes and gives calculations of permeability coefficients.

Chapters 5 and 6 provide a comprehensive survey of ionic relations (compartments and ionic concentrations, ionic fluxes and kinetic models).

Authors consider the electrical properties of membranes in chapter 7 and the action potential in Chapter 8; they study the active transport of cations and anions in *Charophyta* cells (Chapters 9 and 10), the transport and use of carbon dioxide and bicarbonate ions (Chapter 11), and protoplasmic streaming (Chapter 12).

The authors take care to emphasize the general implication of the findings for the plant kingdom, and occasionally for the animal kingdom as well.

Both authors are physicists and they wrote mostly of those aspects of the physiology of giant algal cells which are interesting to biophysicists. Nevertheless, advanced students, teachers and research workers in plant physiology, cell physiology and biophysics will find this book a stimulatory account of an important area of research.

J. N. Rakován

INDEX

Bizot, M.—Dury, M. N.—Pócs, T.: East African Bryophytes, II 1

Dévay, M.—Páldi, E.—Kovács, I.: Thermolabile and thermostable interphases in the vernalization of winter wheat (Triticum aestivum var. Bánkúti 1201) 9

Dézsi, L.—Simon, T.: Investigation of the K-, Ca-, P-, N- and amino-acid content of the epiphytic Hypnum cupressiforme 17

Draskovits, R. M.—Fekete, G.: Chlorophyll concentration and its ecological significance in some species in beechwoods 29

Endrédi, L.—Horváth, I.: Organic matter production and photosynthetic energy utilization of a plant association in loess grassland 39

Gönczöl, J.: Ecological observations on the aquatic Hyphomycetes of Hungary, II ... 51

Juhász-Nagy, P.: Spatial dependence of plant populations. Part 1. Equivalence analysis (An outline for a new model) 61

Kárász, I.: Shrub layer phytomass investigations in the Quercus petraea -Qu. cerris ecosystem of the Síkfőkút research area 79

Kovács, M.: Die Bedeutung der Balaton-Uferzone für den Umweltschutz am See ... 85

Kováts, D.: Phleum studies I. Data on the taxonomy and morphology of Phleum bertolonii DC. and Phleum pratense L. 107

Mészáros, Z.: The Melocactus species of Cuba 127

Péterfi, I.—Nagy-Tóth, F.—Barna, A.: Some results of the researches of Cluj concerning the nutrition of algae 149

Pócs, T.: Bioclimatic studies in the Uluguru mountains (Tanzania, East Africa), II .. 163

Précsényi, I.—Czimber, Gy.—Csala, G.—Szőcs, Z.—Molnár, E.—Melkó, E.: Studies on the growth analysis of maize hybrids (OSSK-218 and DKXL-342) 185

Priszter, Sz.: Über einige Pflanzen des Westlichen Tienschan, II 201

Terpó, A.: The carpological examination of wild-growing vine species of Hungary, I .. 209

Wasser, S. P.—Garibova, L. V.—Mokeeva, V. L.: Morphometry of spores and substantiation of a new system in the genus Agaricus Fr. emend. Karst. 249

Recensiones 259

Printed in Hungary

A kiadásért felel az Akadémiai Kiadó igazgatója — Műszaki szerkesztő: Botyánszky Pál

A kézirat nyomdába érkezett: 1976. II. 7. — Terjedelem: 23,75 (A/5) ív 113 ábra, (5 színes)

76.3245 Akadémiai Nyomda, Budapest — Felelős vezető: Bernát György

ACTA BOTANICA

ТОМ 22 ВЫП. 1–2

ВОСТОЧНО-АФРИКАНСКИЕ МХИ II

М. БИЗОТ, М. Н. ДЬЮРЬ, Т. ПОЧ

Авторы обработали коллекцию мхов, собранную Доктором Лейф Ривардeн (Университет Осло, Норвегия) в Южно-восточной Африке, большая часть которой происходила с горы Муланье, расположенной в южной части Малави, а также проанализировали её точки зрения географического распространения. Большая часть видов новая для территории Малави, а два вида новые для всего африканского континента. Эти виды были ранее известны на Мадарагаскаре, на островах Маскарен.

ПРОДУКЦИЯ ОРГАНИЧЕСКИХ ВЕЩЕСТВ И ИСПОЛЬЗОВАНИЕ ЭНЕРГИИ ФОТОСИНТЕЗА ЛЁССОВО-ЛУГОВЫМИ РАСТИТЕЛЬНЫМИ СООБЩЕСТВАМИ

Л. ЭНДРЕДИ, И. ХОРВАТ

С конца апреля до конца октября 1974 года авторы изучали продукцию органических веществ и использование энергии полевыми растительными сообществами *Salvio-Festucetum rupicolae pannonicum stipetosum*. Самое значительное увеличение в весе наблюдалось в мае и в июне, за это время использование энергии достигало 0,79% и 1,3%. Принимая во внимание все время исследования, оказалось, что продукция сухого вещества надземных частей была 281,94 гр/м, продуктивность равнялась 1,5 гр/м/день, что обозначает 0,17% среднего использования энергии. Сухое вещество содержало 34,5% углеводов и 2,1% азота. Между количеством сухого вещества и продукцией углеводов и азота имеется тесная связь, а между продукцией углеводов и азота имеется более слабая, линейная, регрессивная связь.

ТЕРМОЛАБИЛЬНЫЕ И ТЕРМОСТАБИЛЬНЫЕ СМЕЖНЫЕ-УЧАСТКИ ОЗИМОЙ ПШЕНИЦЫ (TRITICUM AESTIVUM var. BÁNKÚTI 1201) В ПЕРИОД ЯРОВИЗАЦИИ

М. ДЭВАИ, Э. ПАЛДИ, И. КОВАЧ

Авторы изучали количество термостабильных и термолабильных смежных-участков, образующихся в процессе яровизации в озимой пшенице *Tr. aestivum* var. *Bánkúti 1201* при помощи методов яровизации, дэяровизации и обратной яровизации. Стимулирующее влияние развития низкой температуры прекращается 36-часовой обработкой высокой температурой. Дэяровизированность растений зависит от степени яровизации. На основе полученных данных можно сделать вывод, что при яровизации озимой пшеницы существует много термостабильных и термолабильных смежных-участков. Полная обратимость первой стадии яровизации под действием высокой температуры указывает на термолабильность этой стадии. Процессы, проходящие в начале яровизации а также их конечные продукты—термолабильны. После этого термолабильного участка следует смежный термостабильный участок, после которого следует вторая термолабильная фаза. Конечная термостабильная фаза образуется после яровизации и совпадает с её стабилизацией. Опыт определяет место термостабильных и термолабильных смежных участков в процессе яровизации.

ИССЛЕДОВАНИЕ СОДЕРЖАНИЯ K, Ca, P, N и АМИНОКИСЛОТ У ЭПИФИТА HYPNUM CUPRESSIFORME

Л. ДЭЖИ, Т. ШИМОН

Авторы провели изучение фитомассы эпифитного мха на территории «Síkfőkút Project» (Шимон, 1974) и в виде продолжения исследовали содержание K, Ca, P, N и аминокислот у *Hypnum cupressiforme*. Было определено количество этих веществ в живой и мертвой фракции мха, а также в коре, служащей основой. Данные обрабатывали математическистатистическим методом, разницу проверяли пробой. Авторы определили, что во мхе содержиться больше K, однако количество его зависит от характера места обитания. В растениях сухих мест больше K, а в более уравномеренных условиях K может перейти в кору. Обыкновенно Ca больше в коре, или же содержание Ca во мхе и в коре приблизительно одинаковое. В неживых мхах, больше Ca, чем в живых. Динамизм Ca противоположен динамизму K. В растениях содержание P приблизительно в 3 раза больше, чем в коре, а также фракция из живого растения содержит больше P, чем фракция из мертвого растения. В *Hypnum*, растущем в более свежих условиях, содержание азота значительно выше, чем в растениях, растущих в сухих условиях. Содержание азота в растении выше, чем в коре, а внутри растения в живой фракции выше, чем в мертвой. Количество азота значительно выше в мхах растущих в более свежих условиях. Образование содержания аминокислот похоже на азотное. Среди аминокислот выявили: глицин, серин, аспарагиновую кислоту, глютамин, аспарагин, аргинин, лизин, гистидин и цистеин.

На территории в 200 м², принимая во внимание сухой вес подушек эпифита *Hypnum* перечислив на 1 гектар, определили 300 гр. калия, 260 гр. кальция, 150 гр. фосфора, 78 гр. азота и 260 гр. аминокислот.

СОДЕРЖАНИЕ ХЛОРОФИЛЛА В РАСТЕНИЯХ БУКОВЫХ ЛЕСОВ И ЕГО ЭКОЛОГИЧЕСКОЕ ЗНАЧЕНИЕ

Р. ДРАШКОВИЧ, Г. ФЭКЭТЭ

В статье изучались плотность хлорофилла а и б, а также отношение пигментов у 5 доминантных буково-дерновых видов (*Asperula odorata*, *Dentaria bulbifera*, *Melica uniflora*, *Viola alba*, *Carex pilosa*) произрастающих в трех различных по возрасту и строению буковых фондах. Все эти 5 видов отличаются низкой плотностью общего хлорофилла. То, что у двух видов *Dentaria bulbifera* и *Asperula odorata* плотность общего хлорофилла различается в зависимости от возраста растений, можно присвоить световому климату, образующему структуру деревянного фонда. У других трёх видов содержание хлорофилла не зависело от светового климата. Тенденция понижения отношений а и б у одного вида нельзя объяснить понижением среднего значения освещения.

ЭКОЛОГИЧЕСКИЕ НАБЛЮДЕНИЯ НАД ВЕНГЕРСКИМ ВОДНЫМ ГИФОМИЦЕТОМ II
БИОТОПЫ ВОДНЫХ ГИФОМИЦЕТОВ В ЮЖНО-ЗАПАДНОЙ ВЕНГРИИ

И. ГЕНЦЕЛЬ

В статье описывается малоизвестное и необычное местонахождение как биотопы водного гифомицета.

В этих биотопах изучались гниющие под водой листья, в которых наблюдалась настоящая водная а также так называемая — геликоспоровая — секвенция гифомицета. Кроме этого, статья излагает и иллюстрирует конидии образца пены, которая была собрана в необычных, не водных условиях.

ПРОСТРАНСТВЕННАЯ ЗАВИСИМОСТЬ ПОПУЛЯЦИЙ РАСТЕНИЙ I ЧАСТЬ АНАЛИЗ ЭКВИВАЛЕНТНОСТИ (КОНТУРЫ НОВОЙ МОДЕЛИ)

П. ЮХАС-НАДЬ

Многие аспекты пространственной зависимости природных популяций невозожно изучать на основании старых понятий и старыми методами. (Пространственная зависимость содержит такие старые понятия, как «ассоциация между видами», «межвидовая корреляция», «образец-сходство»). Цель этой серии исследований дать целый ряд новых моделей, которые обращают внимание на ранее обойденные проблемы. Специальное значение приобретает пространственно-динамическое приближение (определённые пространственные процессы). Первая наша модель предпринимает определенное обобщение понятия аттрибут-дуализм.

ИЗУЧЕНИЕ ФИТОМАССЫ КУСТАРНИКОГО УРОВНЯ ЭКОСИСТЕМЫ ДУБОВОГО ЛЕСА В ШИКФЁКУТ

И. КАРАС

Статья заключает в себе результаты по изучению фитомассы кустарникового уровня экосистемы дубового леса («Шикфёкут **Project**»). Оценка фитомассы проводилась в августе-сентябре 1973 года методом «средний кустарник», разделяющий материал на подуровни и виды.

ЗНАЧЕНИЕ ЗОНЫ БЕРЕГОВОЙ ЧАСТИ БАЛАТОНА В ЗАЩИТЕ ПРИРОДНЫХ УСЛОВИЙ ОЗЕРА

М. КОВАЧ

Почвы береговой зоны Балатона, благодаря анаэробным условиям, богаты минеральными веществами и поэтому способны адсорбировать большое количество биогенных элементов. Почвы, обладающие большой адсорбционной мощностью проявляют благоприятные фильтровальные способности с точки зрения качества воды.

В результате застройки береговой полосы требуется низкий уровень воды в Балатоне. В случае понижения уровня воды с превращением почвенных условий в аэробные, сохраненный минеральный материал минерализируется и освобожденные биогенные элементы, в основном азот, увеличивают эутрофию озера.

Растения, находящиеся в береговой гоне, в своем организме накопляют большое количество биогенных элементов, в основном калия, фосфора и азота. Растения, растущие на берегу озера с одной стороны «профильтруют», с другой стороны «выфильтруют» попавшие в воду питательные вещества.

ДАННЫЕ К СИСТЕМАТИКЕ И МОРФОЛОГИИ PHLEUM BERTOLONII DC. И PHLEUM PRATENSE L.

Д. КОВАЧ

Автор провел сравнительные морфологические измерения фертильных проростков диплоидного *Ph. bertolonii* DC. ($2n = 14$) и гексаплоидного *Ph. pratense* L. ($2n = 42$). На основании измерений и наблюдений автор заметил, что имелись различия в размерах между клетками эпидермиса стебля, колосков и зерновок, а также между количеством междоузлий и длиной стеблей, принимая во внимание в каждом междоузлии число клубнеподобных вздутий и побегов. Эти исследования проводились с растениями, произрастающими в естественных природных местах, а также на опытном участке.

ВИДЫ MELOCACTUS КУБЫ

З. МЕСАРОШ

Автор в 1974—1975 годах коллекционировал на Кубе кактусы. Автором были собраны уже ранее описанные четыре вида *Melocactus (M. harlowii* Br. et Rose, *acunai* León, *matanzanus* León, *guitartii* León) а также им были найдены и неизвестные виды. *M. jakusii, borhidii, evae, radoczii, nagyii)* В статье, кроме описания новых видов и разновидности видов, автор дает монографию видов *Melocactus*.

НЕКОТОРЫЕ РЕЗУЛЬТАТЫ КЛУЖСКИХ ИССЛЕДОВАНИЙ, КАСАЮЩИХСЯ ПИТАНИЯ ВОДОРОСЛЕЙ

И. ПЕТЕФИ, Ф. НАДЬ-ТОТ, А. БАРНА

В статье дан хронологический обзор важнейших исследований Клужского Университета о питании водорослей. Эти исследования содержат объяснение роли простых (Cu, Zn, Ba, Sr, NH_4, K, Mg, Ca, Na, Li, SO_3, SO_4, CO_3, I, CrO_4, HPO_4, NO_2, NO_3Cl, Br) и сложных (азотно-борных, фосфорно-борных, азотно-фосфорных, азотно-кобальтовых) неорганических и органических питательных веществ (глюциды, аминокислоты, спирты, синтетическая и эндогенная ИУК, экстрагированная из различных растений, гиберилин, аскорбиновая кислота, дегранол, мерапид) в процессе роста и развития в статистических и интенсивных культурах различных линий и видов водорослей из Трансильвании *Chlorella pyrenoidosa*, *Coccomixa dispar*, *Schizochlamys gelatinosa*, *Scenedesmus acutus*, *Sc. acutiformis*, *Sc. obtusiusculus*, *Sc. quadricauda*, *Sc. quadrispina*, *Oocystis pusilla*, *Stichococcus exiguus*, *St. mirabilis*, *St. bacillaris*, *Gloeotila protogenita*, *Pseudopleurococcus printzii*, *Microthamnion kützingianum*, *Stigeoclonium variabile*, *Tribonema ulotrichoides)*.

Действие изученных веществ находилось в связи с водорослями и питательной средой (простая среда Benecke два типа, Knop—Pringsheim, Witsch и более сложная среда Knop—Pringsheim—Felföldy, Tamiya" urea EH", «инитрат А» модифицированная нами среда Tamiya) и это позволяло селектировать чуствительные штаммы-биотесты, которые демонстрируют различные материалы для культур и доказывают необходимость использования некоторого остатка воды для культивирования водорослей.

БИОКЛИМАТИЧЕСКИЕ ИССЛЕДОВАНИЯ В ГОРНОМ МАССИВЕ УЛУГУРУ II (ВОСТОЧНАЯ АФРИКА, ТАНЗАНИЯ

Т. ПОЧ

В статье автор старается выяснить орографию горного массива его климатические условия, а также распределение связей типов вегетации. Косвенным методом были составлены диаграммы Гаусен-Валтер территории дождемерной станции и с их помощью было объяснено горизонтальное и вертикальное распространение растительных сообществ горного массива. Автор определяет вегетационные зоны горы Улугуру:

А. Сухой лес равнинной местности и зона лесной саванны.
Б. Равнинная, наполовину вечнозеленая, дождевая, лесная зона.
В. Сухой лес низкогорной области и зона саванного леса.
Г. Дождевая лесная зона низкогорной области.
Д. Горная дождевая лесная зона.
Е. Зона высокогорного, то есть снежного карликового леса. Два разреза демонстрируют пространственное расположение зональных растительных сообществ.

АНАЛИЗ РОСТА ГИБРИДОВ КУКУРУЗЫ (OSSK-218 и DKXL-342)

И. ПРЕЧЕНЬИ, Д. ЦИМБЕР, Г. ЧАЛА, З. СЁЧ, Э. МОЛЬНАР, Э. МЕЛКО

Статья занимается анализом роста двух гибридов кукурузы (OSSK-218, DKXL-342). Исследования проводились в производственных условиях (Сельскохозяйственный комбинат, Бабольна) в период с 22 мая 1974 года до 15 августа с растениями от 6-ти недельного до 16-ти недельного возраста. Измеряли вес надземных органов растений, а также площадь листа в двухнедельном променяли показательную формулу. На основании формулы каждую неделю определяли вес каждого растения и площадь листа. Зная эти данные, оценяли RGR, NAR, LAR, RLGR, CGR, а также величины эффициенции на каждую неделю. Статья также занимается изменением вышеупомянутых характерностей роста. В статье публикуются данные о связи некоторых климатических фактов (средненельная температура, недельные осадки, общее количество часов солнеч ного освещения) и характера роста, а также корреляция между свойствами роста. В статье обсуждается влияние климатических фактов на вариабильность характера роста, а также влияние ростовых свойств на вариабильность.

О НЕКОТОРЫХ РАСТЕНИЯХ ЗАПАДНОГО ТЯНЬ-ШАНЯ II

С. ПРИСТЕР

Автор дает короткое обозрение истории открытия гибридов *Eremurus*, перечисляет до сих пор известные искуственные и природные гибриды, потом дает имя гибриду *Er. regelii* × *turkestanicus*, найденному в Западном Тянь-Шане (*Eremurus* × *ludmillae* Levitschev et Priszter.) Автор описывает найденный на территории Чатлакского Заповедника новую модификацию *Alcea nudicaulis* (var. *marthae*) затем с того же места дает описание новых "lusus" и форм. В конце автор упоминает некоторые адвентивные растения с территории Ташкента и его окрестностей.

КАРПОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ ДИКОРАСТУЩИХ ВИДОВ ВИНОГРАДА В ВЕНГРИИ I

А. ТЭРПО

Ботанические исследования видов винограда участились особенно с момента появления филоксеры. Автор проводит ботанические изучения дикорастущего винограда в Карпатском Бассейне Венгрии, который особенно характерен для этого места. С конца 1800 года об этом фонде еще не появлялась обстоятельная научная статья. В связи с этой статьёй нужно заметить, что северная граница Венгрии более или менее совпадает с распространением, как *Vitis sylvestris* Gmel., так и с северной границей распространения *Vitis vinifera* L.

Кроме *V. sylvestris*, на упомянутой территории все большее место занимает *V. riparia* Michx. После определения места происхождения обоих видов, в первый раз начинают ботанически систематизировать данные (с девяти мест) о свойствах кисти, ягоды, семян а также данные о связи между размерами и весом ягод.

Первоначальную роль в систематике основных видов винограда играет семя.

Автор называет основными видами те «дикие» виды, которые используют для получения подвоя или благородных сортов винограда (винный, столовый). После того как были сравнены главные размеры семян *V. sylvestris* с размерами семян австрийского винограда рейнской области, эти данные были помещены в виде таблицы с обозначением места произрастающих видов. Подобным образом происходит демонстрация семян *V. riparia*. На основании размеров длины семян автор причисляет семена дикого винограда к различным классам. Многочисленные сравнения автор проводит со свойствами семян *V. vinifera*. С помощью многократных показателей—ширина/длина [в некоторых случаях обратный показатель—длина/ширина], длина клюва/длина семени—автор характеризует семена двух венгерских дикорастущих видов винограда. Делая сравнения с видом *V. vinifera*, автор обрашет внимание на сходство (например, ширина семени) и на различие, как например короткий клюв и широкая халаза.

МОРФОМЕТРИЯ СПОР И ОБОСНОВАНИЕ НОВОЙ СИСТЕМЫ РОДА AGARICUS FR. EMEND. KARST.

С. П. ВАССЕР, Л. В. ГАРИБОВА, В. Л. МОКЕЕВА

Оценка таксономической ценности признаков рода *Agaricus* количество которых включая морфолого-анатомические, культуральные и физиолого—биохимические достигает 43. Изучен, с последующей статистической обработкой, предел варьирования размеров спор 49 видов рода *Agaricus* Северного полушария. Изучены эксикаты (A. H. Smith, Herb. of the University of Michigan, USA; S. Lundell, Fungi exsiccati suecici praesertim Upsalienses, Sweden), экземпляры из разных географических зон, типовые образцы (F. H. Moeller, Herb. Mus. Bot. Hauniense; A. Pilát, Herb. Gen. Mus. Bot. Pragae; G. Bohus, Herb. Musei Hist.-nat. Hung.; P. D. Orton, Herb. Hort. Bot. Reg., Kew), а также коллекции видов рода *Agaricus* большинства ботанических учреждений СССР.

Введен новый стабильный очень важный показатель $К_{ер}$. — отношение длины споры к ее ширине, названный показателем эволюционной продвинутости видов, поскольку круглые споры считаются более примитивными (Singer, 1975), то виды с меньшим $К_{ер}$ оказываются эволюционно более древними, чем с большим. При этом учитывались также характер ареала, численность вида, тип развития, строение трамы, характер внутривидовой изменчивости и т. д.).

В результате анализа комплекса признаков и данных биометрического изучения спор предложена новая система рода *Agaricus*, содержащая 4 подрода, 10 секций, 4 подсекции и 10 серий. Ключ для определения внутриродовых таксонов рода *Agaricus*.

The *Acta Botanica* publish papers on botanical subjects in English, French, German and Russian.

The *Acta Botanica* appear in parts of varying size, making up volumes.

Manuscripts should be addressed to:

Acta Botanica, Budapest 502, Postafiók 24.

Correspondence with the editors and publishers should be sent to the same address.

The rate of subscription is $ 32.00 a volume.

Orders may be placed with "*Kultúra*" Foreign Trade Company for Books and Newspapers (1389 Budapest 62, P.O.B. 149. Account No. 218-10990) or with representatives abroad.

Les *Acta Botanica* paraissent en français, allemand, anglais et russe et publient des travaux du domaine des sciences botaniques.

Les *Acta Botanica* sont publiés sous forme de fascicules qui seront réunis en volumes.

On est prié d'envoyer les manuscrits destinés à la rédaction à l'adresse suivante:

Acta Botanica, Budapest 502, Postafiók 24.

Toute correspondance doit être envoyée à cette même adresse.

Le prix de l'abonnement est de $ 32.00 par volume.

On peut s'abonner à l'Entreprise du Commerce Extérieur de Livres et Journaux «*Kultúra*» (1389 Budapest 62, P.O.B. 149 Compte-courant No. 218-10990) ou à l'étranger chez tous les représentants ou dépositaires.

«*Acta Botanica*» публикуют трактаты из области ботаники на русском, английском, французском и немецком языках.

«*Acta Botanica*» выходят отдельными выпусками разного объема. Несколько выпусков составляют один том.

Предназначенные для публикации рукописи следует направлять по адресу:

Acta Botanica, Budapest 502, Postafiók 24.

По этому же адресу направлять всякую корреспонденцию для редакции и администрации. Подписная цена — $ 32.00 за том.

Заказы принимает предприятие по внешней торговле книг и газет «*Kultúra*» (1389 Budapest 62, P.O.B. 149. Текущий счет № 218-10990), или его заграничные представительства и уполномоченные.

Reviews of the Hungarian Academy of Sciences are obtainable at the following addresses:

AUSTRALIA

C. B. D. Library and Subscription Service
Box 4886, G. P. O.
Sydney N. S. W. 2001

Cosmos Bookshop
145 Acland St.
St. Kilda 3182

AUSTRIA

Globus
Höchstädtplatz 3
A—1200 Wien XX

BELGIUM

Office International de Librairie
30 Avenue Marnix
1050-Bruxelles

Du Monde Entier
162 Rue du Midi
1000—Bruxelles

BULGARIA

Hemus
Bulvar Ruszki 6
Sofia

CANADA

Pannonia Books
P. O. Box 1017
Postal Station "B"
Toronto, Ont. M5T 2T8

CHINA

C N P I C O R
Periodical Department
P. O. Box 50
Peking

CZECHOSLOVAKIA

Mad'arská Kultura
Národní třida 22
115 66 Praha

PNS Dovoz tisku
Vinohradská 46
Praha 2

PNS Dovoz tlače
Bratislava 2

DENMARK

Ejnar Munksgaard
Nörregade 6
DK—1165 Copenhagen K

FINLAND

Akateeminen Kirjakauppa
P. O. Box 128
SF-00101 Helsinki 10

FRANCE

Office International de Documentation et Librairie
48, Rue Gay-Lussac
Paris 5

Librairie Lavoisier
11 Rue Lavoisier
Paris 8

Européridiques S. A.
31 Avenue de Versailles
78170 La Celle St.-Cloud

GERMAN DEMOCRATIC REPUBLIC

Haus der Ungarischen Kultur
Karl-Liebknecht-Strasse 9
DDR—102 Berlin

Deutsche Post
Zeitungsvertriebsamt
Strasse der Pariser Kommüne 3—4
DDR-104 Berlin

GERMAN FEDERAL REPUBLIC

Kunst und Wissen
Erich Bieber
Postfach 46
7 Stuttgart s

GREAT BRITAIN

Blackwell's Periodicals
P. O. Box 40
Hythe Bridge Street
Oxford OX1 2EU

Collet's Holdings Ltd.
Denington Estate
London Road
Wellingborough Northants NN8 2QT

Bumpus Haldane and Maxwell Ltd.
5 Fitzroy Square
London W1P 5AH

Dawson and Sons Ltd.
Cannon House
Park Farm Road
Folkestone, Kent

HOLLAND

Swets and Zeitlinger
Heereweg 347b
Lisse

Martinus Nijhoff
Lange Voorhout 9
The Hague

INDIA

Hind Book House
66 Babar Road
New Delhi 1

India Book House
Subscription Agency
249 Dr. D. N. Road
Bombay

ITALY

Santo Vanasia
Via M. Macchi 71
20124 Milano

Libreria Commissionaria Sansoni
Via Lamarmora 45
50121 Firenze

JAPAN

Kinokuniya Book-Store Co. Ltd.
826 Tsunohazu 1-chome
Shinjuku-ku
Tokyo 160—91

Maruzen and Co. Ltd.
P. O. Box 5050
Tokyo International 100—31

Nauka Ltd.-Export Department
2—2 Kanda
Jinbocho
Chiyoda-ku
Tokyo 101

KOREA

Chulpanmul
Phenjan

NORWAY

Tanum-Cammermayer
Karl Johansgatan 41—43
Oslo 1

POLAND

Węgierski Instytut Kultury
Marszalkowska 80
Warszawa

BKWZ Ruch
ul. Wronia 23
00—840 Warszawa

ROUMANIA

D. E. P.
Bucureşti

Romlibri
Str. Biserica Amzei 7
Bucureşti

SOVIET UNION

Sojuzpechatj — Import
Moscow

and the post offices in each town
Mezhdunarodnaya Kniga
Moscow G—200

SWEDEN

Almqvist and Wiksell
Gamla Brogatan 26
S—101 20 Stockholm

A. B. Nordiska Bokhandeln
Kunstgatan 4
101 10 Stockholm 1 Fack

SWITZERLAND

Karger Libri AG.
Arnold-Böcklin-Str. 25
4000 Basel 11

USA

F. W. Faxon Co. Inc.
15 Southwest Park
Westwood, Mass. 02090

Stechert-Hafner Inc.
Serials Fulfillment
P. O. Box 900
Riverside N. J. 08075

Fam Book Service
69 Fifth Avenue
New York N. Y. 1003

Maxwell Scientific International Inc.
Fairview Park
Elmsford N. Y. 10523

Read More Publications Inc.
140 Cedar Street
New York N. Y. 10006

VIETNAM

Xunhasaba
32, Hai Ba Trung
Hanoi

YUGOSLAVIA

Jugoslavenska Knjiga
Terazije 27
Beograd

Forum
Vojvode Mišičal
21000 Novi Sad

18. II. 1977

Index: 26.001

ACTA BOTANICA

ACADEMIAE SCIENTIARUM HUNGARICAE

ADIUVANTIBUS

A. BORHIDI, G. L. FARKAS, G. FEKETE, V. FRENYÓ,
T. HORTOBÁGYI, P. JUHÁSZ-NAGY, I. MÁTHÉ, S. SÁRKÁNY,
T. SIMON, R. SOÓ, B. ZÓLYOMI

REDIGIT

P. JAKUCS

TOMUS XXII FASCICULI 3–4

AKADÉMIAI KIADÓ, BUDAPEST
1976

ACTA BOT. HUNG.

ACTA BOTANICA

A MAGYAR TUDOMÁNYOS AKADÉMIA BOTANIKAI KÖZLEMÉNYEI

SZERKESZTŐSÉG ÉS KIADÓHIVATAL: 1054 BUDAPEST, ALKOTMÁNY UTCA 21.

Az *Acta Botanica* német, angol francia és orosz nyelven közöl értekezéseket a botanika tárgyköréből.

Az *Acta Botanica* változó terjedelmű füzetekben jelenik meg, több füzet alkot évenként egy kötetet.

A közlésre szánt kéziratok a következő címre küldendők:

Acta Botanica, Budapest 502, Postafiók 24.

Ugyanerre a címre küldendő minden szerkesztőségi és kiadóhivatali levelezés.

Megrendelhető a belföld számára az „Akadémiai Kiadó"-nál (1363 Budapest Pf 24. Bankszámla 215.11128), a külföld számára pedig a „Kultúra" Külkereskedelmi Vállalatnál (1389 Budapest 62, P.O.B. 149. Bankszámla 218-10990) vagy annak külföldi képviseleteinél, bizományosainál.

Die *Acta Botanica* veröffentlichen Abhandlungen aus dem Bereiche der botanischen Wissenschaften in deutscher, englischer, französischer und russischer Sprache.

Die *Acta Botanica* erscheinen in Heften wechselnden Umfanges. Mehrere Hefte bilden einen Band.

Die zur Veröffentlichung bestimmten Manuskripte sind an folgende Adresse zu senden:

Acta Botanica, Budapest 502, Postafiók 24.

An die gleiche Anschrift ist auch jede für die Redaktion und den Verlag bestimmte Korrespondenz zu richten. Abonnementspreis pro Band: $ 32.00.

Bestellbar bei dem Aussenhandels-Unternehmen »*Kultúra*«(1389 Budapest 62, P.O.B. 149 Bankkonto Nr. 218-10990) oder bei seinen Auslandsvertretungen und Kommissionären.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (3—4), pp. 269—293 (1976)

MASS OF WEEDS AND THE FREQUENCY OF WEED SPECIES AFFECTED BY HERBICIDES IN A LUPIN CULTURE-CONSOCIATION

By

F. BORBÉLY, I. BORBÉLY, E. ELEK and M. KECSKÉS

AGROTECHNICAL RESEARCH INSTITUTE OF NYÍRSÉG, NYÍREGYHÁZA, RESEARCH INSTITUTE FOR SOIL SCIENCE AND AGRICULTURAL CHEMISTRY OF THE HUNGARIAN ACADEMY OF SCIENCES, BUDAPEST

(Received January 10, 1976)

The effect of 108 contact, soil and systemic herbicide preparations belonging to 24 different chemical groups was studied with respect to occurrence of weed species in the *Lupinus* culture-consociation at the end of summer, the phytomass of weeds, the individual number of *Lupinus albus* and *L. luteus* as well as their biological productions (seed) in Nyírség at the main lupin-growing area of Hungary. These were carried out in small plot experiments on slightly brown forest soil in 1971, 1972, and 1973.

The herbicides were used preemergently in 3.5 kg/ha doses on the basis of experience drawn from earlier experiments. The weed-phytomass-decreasing effect of the studied herbicides, that is the indirect effect promoting the biological production of *Lupinus* species investigated with the above listed parameters was evaluated for the 108 preparations one by one and according to the larger chemical groups too.

The frequency of occurrence of the most dominant weed species at the experimental site: in the case of *Setaria glauca* was reduced by the preparations belonging to carbamide, triazine and uracyl derivatives and the herbicide combinations. The *Setaria glauca* proved to be tolerant and resistant to 74% of the applied herbicides. In contrast to this, the *Chenopodium album* was sensitive to 65% of the herbicides.

According to the analyses of the weed number at the end of summer, more than one-third (42) of the investigated herbicides were reduced by more than 50%.

The weight of weeds decreased likewise by more than half (56) of the herbicides. This indicates the great importance of measuring the weight of weeds.

On the basis of the individual number and production (seed-corn) of the studied culture plants *L. albus* was less sensitive of the two lupin species of the same genus to the investigated herbicides.

There was no significant difference on comparing the effectiveness of every single chemical group summarized with the group of combinations containing two herbicides, but it should be noted that only 16 combinations were used from the 108 preparations.

Evaluating the combinations and preparations containing only one active ingredient, many of them were found to be promising for both *Lupinus* species such as linuron (the Linuron 50) in the case of *Lupinus albus* diuron (Karmex) in the culture of *Lupinus luteus* lenacil (Venzar) and the combination of promethryne-simazine (Camparol, 1803).

I. Introduction

The herbicides could narrow down the reactions of weed species given in some dimensions of the niche (FEKETE, 1975) by the inhibition of photosynthesis and germination: causing general growing disorder, poisoning of respiration and the biosynthesis of chloroplasts, inhibition etc. and other so far unknown factors could also play a part (FRYER and EVANS, 1968: UBRIZSY and GIMESI, 1969).

One of the most timely problems of our age not only from an agricultural, but biological point of view is just how and to what extent the herbicides — being xenobiotics — on account of their ecophysiological effect inhibit the weed flora growth in all weed species of the biological production and agrarian ecosystems. This problem can only be solved by the coordinated biological and agricultural research. As regards the investigation on the primary production of arable fields (as a previous survey to the above mentioned problem) an excellent example of the works of MÁTHÉ and PRÉCSÉNYI (1968,1971 carried out on the IBP sampling area of Ujszentmargita is referred to.

The coenological, ecological investigations stretching back to many decades of weed plant associations of agrarian and natural ecosystems in Hungary (BALÁZS, 1952; BODROGKÖZY, 1959; FELFÖLDY 1952; GONDOLA 1964, 1966, 1969; JEANPLONG 1951, 1955; Soó 1964—1973; TIMÁR 1954; TIMÁR—UBRIZSY 1957; UBRIZSY 1950, 1955 etc.) have provided a valuable basis for solving the problem.

Investigations in Nyírség have been useful for our work (Soó 1933, 1934, 1938, 1939, 1964—1973; ASZÓD 1935; GONDOLA 1964, 1966, 1969).

With regard to the weed control research and experience in Hungary of the last decades we refer to the comprehensive works of the past years (UBRIZSY 1968; UBRIZSY and GIMESI 1969; KÁDÁR 1973).

According to the data of the literature (UBRIZSY and GIMESI 1969), the *Setaria* species could be chemically eradicated only with great difficulty and the *Chenopodium* species are dangerous to the culture plant species. On the basis of the weed coenological registration (UJVÁROSI 1952) the *Setaria glauca* is 5th in the order of overgrowth of weeds and *Chenopodium album* is 4th in Hungary. E.g. the dominance of *Setaria* species has been reported recently by MÁTHÉ and PRÉCSÉNYI (1971) in ploughed and stubble-field from other parts of Hungary. According to data on Nyírség, these species are dominant in weed plant associations of this area too. In the order of overgrowth the *Setaria glauca* is the 3rd, the *Chenopodium album* is the 7th in the Nyírség (GONDOLA 1964).

Although neither occurring weed species of weed flora of agrarian ecosystems can be neglected, the primary aim of weed control should be directed at weed species, the most harmful to culture plants, however, the general tendency of agricultural practice is to per manently liquidate the weed species in the culture ecosystems (UBRIZSY 1960, VAN DERZEPP 1972).

Of the herbicides used nowadays 80% are effective to the dicotyledons and 203 of them to the monocotyledons (RAYNAUD 1971) but from time to time the monocotyledons seriously jeopardized the biological production ;of culture plants.

In the interests of avoiding the unilateral effects influencing the weed coenosis which could result in a shift to the herbicide-resistant species in the floristic composition of the weed stand or which leads to the formation of the more sensitive weed species, it is very important to rotate the herbicides (HARPER 1957, UBRIZSY 1960, VERSATZ 1963).

Concerning the chemical weed control of legumes in Hungary, extensive investigations have been carried out by UBRIZSY (1962), GIMESI (1964, 1965, 1969, 1971, 1972, 1975), GIMESI and UBRIZSY (1964) and UBRIZSY and GIMESI (1969). On lupin, only UBRIZSY (1962) and GIMESI and UBRIZSY (1971) have published data.

In the last decades during our herbicide selection investigations of *Lupinus albus* and *L. luteus* cultures we studied the effect of herbicides on the *Lupinus* species *Rhizobium* strains belonging to different species (especially lupini) and their symbiosis considering the expressed demand of agricultural production as well as the protection of the environment. As a conclusion, the herbicides having a perspective in weed control of *Lupinus albus* and *L. luteus* have been given.

In this paper we present the results of investigations on the influence of herbicides on the weed flora of *Lupinus* culture-consociation in the aspect

at the end of summer from 1971—1973. We would like to give data from biological and agricultural points of view for the better knowledge of the changes of weed flora of Nyirség affected by xenobiotics (pesticides).

Therefore here firstly the data concerning the weed phytomass-decreasing effect of studied herbicides and their acting spectra determining the occurrence of weed species will be discussed. The qualitative and quantitative effect of herbicides on *Lupinus* and *Rhizobium* species and their biological production (BORBÉLY J., BORBÉLY, F., ELEK and KECSKÉS 1973, 1974, BORBÉLY and KECSKÉS 1972, ELEK BORBÉLY J., BORBÉLY F., ELEK and KECSKÉS 1973, 1974, KECSKÉS, BORBÉLY J., BORBÉLY F. and ELEK 1972, 1975, KECSKÉS, ELEK, BORBÉLY, J. and BORBÉLY F. 1972a, 1973 will be detailed only partially and only for the better understanding of the problem raised in the title.

II. Materials and methods

Investigations were carried out at one site of the main lupin-growing area of the region of Nyírség in Hungary in slightly acidic brown forest soil of which a few characteristics are demonstrated in Table 1. The principal meteorological data of the vegetation periods are shown in Table 2.

Table 1

General soil science laboratory test of sites of Gyulatanya

	pH		Total N %	Available nutrient			Saturation percentage*	Capillary rise		Humus, %
	H_2O	KCl		N	P_2O_5	K_2O		3 h	5 h	
1971										
0—10 cm	5.2	4.5	0.047	2.55	25.5	21.4	29	305	355	1.60
0—20 „	5.3	4.6	0.027	5.59	19.4	41.1	29	280	320	1.69
20—40 „	5.6	5.0	0.048	5.30	33.4	38.7	29	270	2?0	1.60
40—60 „	5.5	4.7	0.043	3.90	7.2	16.2	30	290	310	1.30
1972										
0—10 cm	5.9	5.2	0.032	0.98	26.3	14.3	29	320	350	1.09
0—20 „	5.8	5.3	0.043	0.29	43.1	15.0	29	325	370	1.27
20—40 „	5.8	5.0	0.037	1.08	15.5	16.7	30	280	320	1.06
40—60 „	6.5	5.4	0.030	0.54	4.7	5.0	29	380	400	0.70
1973										
0—10 cm	6.2	5.1	0.024	0.54	14.1	36.2	30	270	300	1.32
0—20 „	6.2	4.8	0.037	0.49	13.1	29.5	29	270	330	1.23
20—40 „	6.1	4.9	0.035	0.49	10.6	26.0	30	200	260	0.94
40—60 „	6.5	5.3	0.033	0.88	4.1	22.5	29	250	290	1.10

* Sticky point according to ARANY.

Table 2

Main meteorological data of vegetation periods of Lupinus albus and L. luteus in the experimental years

	March	April	May	June	July	August	September
Monthly mean temperature							
1971	1.6	10.8	17.6	17.9	19.8	20.8	13.5
1972	6.5	12.1	16.2	19.2	22.3	19.6	13.2
1973	4.5	9.5	15.5	18.1	20.6	19.9	16.7
20 years' average of temperature (1952—1971)	3.4	10.0	14.8	19.4	20.6	20.0	15.9
Precipitation in mm	11.3	16.2	65.7	65.2	40.1	24.8	49.8
1971							
1972	15.1	74.8	62.2	51.9	30.4	70.9	73.6
1973	5.6	40.3	52.9	109.0	119.1	9.2	11.7
20 years' average of temperature (1952—1971)	27.0	40.5	48.4	86.1	69.4	62.9	44.3

In the course of the selection investigations from 1971—1973, 108 herbicides were studied: 52 in 1971, 30 in 1972 and 26 tested in 1973. Eight of them used in 1971: the A 2591, Camparol 1803, Gesatop 50, Hoe 2849, Karmex, Kloben, Merkazin, Venzar were repeatedly investigated in 1972 too. Beside the 26 herbicides tested in 1973 the Gesatop 50, Venzar as well as Planavin 75 studied already in 1971 were applied repeatedly. This was done because of their suitable properties experienced in the experiments of earlier years. In this way the effect of 119 treatments was registered over a three-year period. The 108 herbicides are listed in 24 chemical groups (Table 3). The trade name was used in this work, because, according to our experience, e.g. two preparations having the same active ingredients resulted in different control effects. The herbicides were applied preemergently (the postemergent applications proved to be disadvantageous) 3.5 kg/ha doses of herbicides with 600 l water/ha were sprayed uniformly on 4 m^2 plots using quadruplicates, and the seeds of *Lupinus albus* Neoalba G T and *Lupinus luteus* Gyulatanya 784 were sown into them.

Evaluating herbicide efficiency starting from SCHROTER and STEBLERS' (1890, cit. BALÁZS 1948) basic work and considering the cultivation points of view, in addition to the individual number and seed crop of lupins/plots, we also registered on the 1/4 m^2 sample space, the weight (together) of weeds occurring at the end of summary in the lupin culture-consociation as well as the number of weeds according to species.

The RAUNKIAER system modified by UJVÁROSI (1952, 1973) was used for marking the life forms. According to the type of the experiments for demonstrating frequency values (Table 4, 5, 6) the letter marks used by GONDOLA (1966) were applied modified by us to some extent with the introduction of "f" = species occurring in all four replications but their individual number was not less than 5 and not more than 30; F = frequent (species occurring in all four replications with more than 30 individual numbers); s = subfrequent (species occurring in two—three replications only); a = accident (species occurring only in one plot). After the frequency marks the effective individual number of weeds/1 m^2 were written. The registrations of weeds were made after ripening in 1971 8—14 of September, in 1972 11—16 of August, and in 1973 12—18 of September.

III. Results and discussion

The number of weed species occurring in the three experimental sites (not far from each other) representing culture-ecosystem formed on slightly brown forest soil was altogether 20 (5 monocotyledons and 15 dicotyledons):

Table 3

List of herbicides used in the investigations

Trade name	Common name	Chemical name
A) CONTACT HERBICIDES		
I. Nitro-compounds:		
1. Amine 20%	dinoseb-amine	DNBP amine-solution
2. Aretit	dinoseb-acetate	2,4-dinitro-6-s-butylphenol acetate
3. BNP 20	dinoseb = DNBP	2,4-dinitro-6 a butylphenol
4. DNBP 20	dinoseb = DNBP	2,4-dinitro-6-s-butylphenol
5. Hoe 2904	dinoseb-acetate	2,4-dinitro-6-s-butylphenol acetate
6. Krezonit E	DNOC	2,4-dinitro-o-crezol
7. Raphatox	DNOC	2,4-dinitro-o-crezol
II. Chlorinated phenols:		
8. TOK E-25	nitrophen	2,4-dichlorophenyl-4'-nitrophenyl ether
B) SYSTEMIC HERBICIDES		
Phenoxy-alkyl-carboxylic acids and their derivatives		
III. 2,4,5-trichloro-phenoxy acetic acid and its esthers:		
9. Trifenoxin 80	2,4,5-T	2,4,5-trichlorophenoxyacetic acid
IV. 2,4-dichlorophenoxy acetic acid and its salts and esthers:		
10. Lironox	2,4-D-amine	2,4-D dichlorophenoxyacetic acid amine
V. Chloro-crezoxy-acetic acid salts:		
11. Dikotex 40	MCPA	4-chloro-2-methylphenoxyacetic acid
12. M 52	MCPA-potassium	K-salt of 4-chloro-2-methylphenoxyacetic acid
VI. Phenoxy propionic acid derivatives:		
13. MP 58	mecoprop-potassium	K-salt of (±)-2-(4'-chloro-2'-methylphenoxy) propionic acid
14. Sys 67 I	mecoprop	(±)-2-(4'-chloro-2'-methylphenoxy) propionic acid
15. Sys 67 II	mecoprop	(±)-2-(4'-chloro-2'-methylphenoxy) propionic acid
VII. Other phenoxy derivatives:		
16. Bexone	MCPB	4-(4'-chloro-2'-methylphenoxy)-butyric acid
17. Dyserbo	2,4-DEN	2,4-dichloro-phenoxyethanol
18. Embutor E	2,4-DB-buthylesther	butylesther of 2,4 DB
19. Embutor	2,4-DB-buthylesther	

Table 3 cont.

Trade name	Common name	Chemical name
20. Legumex D	2,4-DB	4-(2',4'-dichlorophenoxy)butyric acid
21. Legumex M	MCPB	4-(4'-chloro-2'-methylphenoxy)-butyric acid
22. Sys 67/B	2,4-DB	4-(2',4'-dichlorophenoxy)-butyric acid
23. Tropotox	MCPB	4-(4'-chloro-2'-methylphenoxy)-butyric acid
VIII. Other substituted halogenic acids:		
24. Vegiben	chloramben	3-amino-2,5-dichlorobenzoic acid
IX. Halogenized aliphatic carbonic acids:		
25. NaTa	TCA	Na-trichloro acetate
X. Alpha-chlor-acetamides:		
26. Legurame	carbetamide	phenyl-carbamoyl-oxy-2-N-ethyl propion amide
XI. Anilides:		
27. Dymid	diphenamid	N,N-dimethyl-2,2-diphenylacetamide
28. DCPA	propanil	3,4-dichloro propion anilide
29. Hortox	CMA	N'-(3-chloro-4-methylphenyl)-2-methyl-pentane-amide
30. Potablan	monalide	alfa, alfa-dimethyl valerianic acid-4-chloro-amilide
31. Ramrod	propachlor	2-chloro-N-isopropyl-N-phenylacetamide
32. Satecid	propachlor	2-chloro-N-isopropyl-N-phenylacetamide
33. Stam F 34/A	propanil	N-(3,4-dichlorophenyl)propionamide
34. Stam F 34	propanil	N-(3,4-dichlorophenyl)propionamide
Carbamates		
XII. Phenyl-carbamates:		
35. Betanal	phenmedipham	3-methoxy-carbonyl-amino-phenyl-N-(3'-methylphenyl) carbamate
36. Hungarian CIPC	chlorpropham	isopropyl-N-(3-chlorophenyl) carbamate
37. Prevenol	chlorpropham	isopropyl-N-(3-chlorophenyl) carbamate
XIII. Thiocarbamates:		
38. Avadex	triallate	S-2,3,3-dichloroalkyl-N,N-diisopropyl thio-carbamate
39. Basamid	dazomet	3,4,5,6-tetrahydro-3,5-dimethyl-1,3,5-thiadiazine-2-thione
40. Campione	E.P.T.C.	S-ethyl-N'N-dipropyl-thiocarbamate
41. Ordram	molinate	N-hexamethylene-S-ethyl-thiocarbamate
42. Tillam 6 E	pebulate	S-propyl-N-butyl-N-ethyl-thiocarbamate
43. Vegadex	sulfallate	diethyl-dithio-carbamate acid-chloroalkyl-ester
44. Vernam	vernolate	S-propyl-N,N-dipropyl-thiocarbamate

Table 3 cont.

Trade name	Common name	Chemical name
XIV. Urea derivatives:		
45. Afalon	linuron	N-(3,4-dichlorophenyl)-N'-methoxy-N'-methylurea
46. Cotoran	fluometuron	N'-(3-trifluoromethylphenyl)-N,N-dimethyl-urea
47. DCU F	DCU	N,N-bis-(2,2,2-trichloro-1-hydroxy-ethyl) urea
48. DCU P	DCU	N,N-bis-(2,2,2-trichloro-1-hydroxy-ethyl) urea
49. Diralid	DCU	N,N-bis-(2,2,2-trichloro-1-hydroxy-ethyl) urea
50. Kloben	neburon	N-butyl-N'-(3,4-dichlorophenyl)-N-methyl-urea
51. Karmex	diuron	N-(3,4-dichlorophenyl)-N',N'-dimethylurea
52. Linuron 50	linuron	N-(3,4-dichlorophenyl)-N'-methoxy-N'-methylurea
53. Lorox	linuron	N-(3,4-dichlorophenyl)-N'-methoxy-N'-methylurea
54. Maloran	chlorbromuron	N-(4-bromophenyl-3-chlorophenyl)-N'-methoxy-N'-methylurea
55. Patoran	metobromuron	N'-(4-bromophenyl)-N-methoxy-N-methyl-urea
56. R. Eptapur	buturon	N'-(4-chlorophenyl)-N-isobutynyl-N-methylurea
57. Tenoran	chloroxuron	(N'-4-(4'-chlorophenoxy)-phenyl)-N,N-dimethylurea
58. Tribunil	methabenztiazuron	N,N-dimethyl-N'-(2-benzthiazolyl)urea
59. Telvar	monuron	N-(4-chlorophenyl)-N',N'-dimethylurea
XV. Benzo-nitrile and thioamide derivatives:		
60. Casoron 133	dichlobenil	2,6-dichlorobenzonitrile
61. NPH/1264	bromoxynil	K-salt of 3,5-dibromo-4-hydroxybenzo-nitrile
62. NPH/1254	ioxynil	Na-salt of 3,5-diiodo-4-hydroxybenzo-nitrile
63. Prefix	chlortiamid	2,6-dichlorothiobenzamide
XVI. Phthalic acid esters:		
64. Dachtal	DCPA	dimethyl-2,3,5,6-tetrachloroterephthalate
Different cyclic carbonic acid derivatives		
XVII. Hexa-hydro-phthalate:		
65. Aquathol G	endothal	7-oxabicyclo-(2,2,1)-heptane-2,3-dicarboxylic acid-disodium salt
66. Endothal	endothal	7-oxabicyclo-(2,2,1)-heptane-2,3-dicarboxylic acid-disodium salt
67. Hydratol	endothal	7-oxabicyclo-(2,2,1)-heptane-2,3-dicarboxylic acid-disodium salt

Table 3 cont.

Trade name	Common name	Chemical name
XVIII. Triazine derivatives:		
68. WL 19805 (Bladex)	cyazine	2-(4-chloro-6 ethyl-amino-1,3,5-triazine-2-yl amino)2 methyl-propionitrile
XIX. Alkyl-amino-chloro-triazines:		
69. Aktikon	atrazine	2-chloro-4-isopropylamino-6-aethylamino-1,3,5-triazine
70. A 2591	secbumeton	4-aethylamino-2s-butylamino-6-methoxy-1,3,5-triazone
71. Etazin	secbumetine	2-methoxy-4-aethylamino-6s-butylamino-1,3,5-triazine
72. Gesatop 50	simazine	2-chloro-4,6-bis(aethylamino)-1,3,5-triazine
73. Gesaprim 50	atrazine	2-chloro-4-aethylamino-6-isopropylamino-1,3,5-triazine
XX. Mercapto-triazines:		
74. Gesagard 50	prometryne	2,4-bis(isopropylamino)-6-methylthio-1,3,5-triazone
75. Gesapax 50	ametryne	2-aethylamino-4-isopropylamino-6-methyl-thio-1,3,5-triazine
76. Igran 50	terbutryne	2-methylthio-4-aethylamino-6-t-butyl-amino-1,3,5-triazine
77. Igran 2105	terbutryne	2-methylthio-4-aethylamino-6-t-butyl-amino-1,3,5-triazine
78. Igran 80	terbutryne	2-methylthio-4-aethylamino-6-t-butyl-amino-1,3,5-triazine
79. Merkazin	prometryne	2,4-bis(isopropylamino)-6-methylthio-1,3,5-triazine
80. Semeron	desmetryne	2-isopropylamino-4-methylamino-6-methylthio-1,3,5-triazine
Other herbicidal active ingredients		
XXI. Heterocyclic compounds:		
81. Amitrol TL	amitrol-rodamid	3-amino-1,2,4-triazolonium-rodamide
82. Amino Triazole	amitrol	3-amino-1,2,4-triazole
83. Hyvar	bromacil	5-bromo-3-s-butyl-6-methyl uracil
84. Pyramin	pyrazon	5-amino-4-chloro-2-phenylpyridazin-3(2H)-one
85. Sinbar	terbacil	3-t-butyl-5-chloro-6-methyl uracil
86. Venzar	lenacil	3-cyclohexyl-5,6-trimethylene uracil
XXII. Anilines:		
87. Planavin 75	nitraline	2,6-dinitro-4-methylsulphonyl-N,N-dipropylaniline
88. Treflan	trifluralin	2,6-dinitro-N,N-dipropyl-4-trifluoromethyl analine

Table 3 cont.

Trade name	Common names of components
C) OTHER HERBICIDES	
XXIII. Combinations:	
89. Aniten D	2,4-D + flurenol (as dimethylamino salts)
90. Aniten M	MCPA + flurenol (as dimethylamino salts)
91. Atracil C	ioxynil + mecoprop (as the potassium salts)
92. Banvel D	dicamba + 2,4-D
93. Camparol 1803	promethryne + simazine
94. Cartex-M	propachlor + monolinuron + promethryne
95. Chlorflurazole	chlorflurazole + MCPA
96. Embutox plus	2,4-DB + MCPA
97. Gesaprim 1802	ametrine + atrazine
98. Gesaran	methoprotryn + simazine
99. Hoe 2849	dinoseb-acetate + monolinuron
100. Liro-Betarex	propham + diuron
101. Murbetol	endothal-Na + propham
102. Tonitox	aktinit PK + chlorophenoxyacetic acid + DNOC
103. Trimetrin	aktinit PK + 2,4-D-Na + DNOC-salt
104. Tropotox plus	MCPB + MCPA-Na
XXIV. Experimental preparations (active ingredients are not published)	
105. Banlene plus	33.3% dinosebacetate + 8.3% linuron
106. Hoe 2913	
107. Hoe 2918	20% monolinuron + chloral-chloroacetamide
108. Hoe 2745	75% chloral-chloroacetamide

14 in 1971, 16 in 1972 and 14 in 1973. (Tables 4, 5, 6). The distribution by species is demonstrated in Fig. 1.

The ratio of the monocotyledons/dicotyledons was the following 4/10 in 1971, 3/13 in 1972, 4/10 in 1973. Of the 20 weed species 9 occurred in all three years and in the three experimental sites. 4 of the 9 constant species: *Digitaria sanguinalis*, *Echinochloa crus-galli*, *Setaria glauca* and *Chenopodium album* proved to be dominant every three years, 5 of the constant species the *Vicia hirsuta* (12), *Amaranthus retroflexus* (39), *Polygonum aviculare* (5), *Polygonum convolvulus* (57), *Polygonum lapathifolium* (32) occurred in all three years in every experimental site, but as the number in the brackets indicates they occurred only sparsely, considering the 432 mapping spaces and only in a few cases in all the replications of the same treatment.

Agropyron repens, *Equisetum arvense*, *Trifolium arvense*, *Hibiscus trionium*, *Convolvulus arvensis*, *Cirsium arvense*, *Erigeron acris*, *Melandrium album*, *Cannabis sativa*, *Lamium purpureum* and *Sinapis arvensis* are considered as accident species, because none of them were found in all three years that is none of them occurred in all the experimental sites and never in four replications of the same treatments. These 11 accident species were only registered altogether in 67 replications of different treatments during the three years with the exception of *Convolvulus arvensis* which was found in 17 replications (Table 5) of the treatments of 1972, the other 10 species occurred only in 10 or less treatments (Table 4, 5, 6). Their number and weight were insignificant.

The relatively high number of the accident weed species could be explained by the agrotechnique conducted on these experimental sites for a very long time systematically. This is justified by the fact that sometimes we found those species, which did not occur in the control plots.

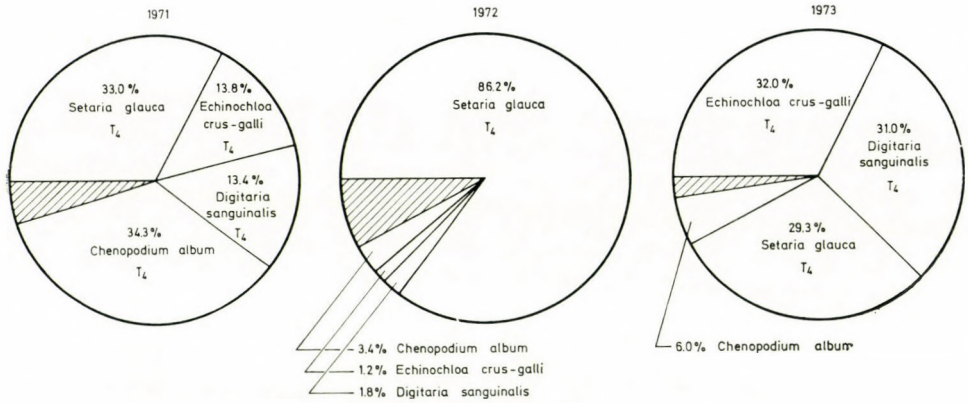


Fig. 1. Frequency of weed species (%) in the lupin culture-consociation. (In non-disturbed hoed and herbicide-treated plots of site)

T_4	Polygonum aviculare	2.66	T_4	Polygonum convolvulus	2.00
T_4	Polygonum convolvulus	1.03	G_3	Convolvulus arvensis	1.19
T_4	Amaranthus retroflexus	0.75	T_2	Vicia hirsuta	1.13
T_4	Polygonum lapathifolium	0.42	G_3	Cirsium arvense	0.84
T_4	Trifolium arvense	0.03	T_4	Cannabis sativa	0.52
G_3	Convolvulus arvensis	0.03	T_4	Amaranthus retroflexus	0.49
T_2	Vicia hirsuta	0.02	T_4	Hybiscus trionum	0.29
H_3	Melandrium album	0.01	T_4	Polygonum lapathifolium	0.29
G_1	Agropyron repens	0.01	T_4	Trifolium arvense	0.20
T_4	Cannabis sativa	0.01	HT	Erigeron acris	0.17
	altogether:	4.97	T_4	Polygonum aviculare	0.08
			H_3	Melandrium album	0.05
				altogether:	7.25

T_4	Polygonum aviculare	1.00
HT	Brigeron acris	0.21
T_4	Hibiscus trionum	0.14
T_4	Amaranthus retroflexus	0.14
T_4	Polygonum convolvulus	0.14
T_2	Vicia hirsuta	0.10
T_3	Sinapis arvensis	0.07
T_1	Lnium purpurcum	0.03
T_4	Polygonum lapathifolium	0.03
G_1	Equisetum arvense	0.07
	alltogether:	1.93

From the dominant species listed above the *Setaria glauca* was the most resistant to the herbicides, as it can be seen in Fig. 2 where only a few more active herbicides are given.

As it can be seen in Fig. 2 and Tables 4, 5 and 6, among the 108 herbicides applied mainly 7 of carbamides, 7 of triazines and 2 of uracils as well as from the 16 herbicide combinations 5 preparations killed remarkably the *Setaria glauca*. In addition to the inhibitory effect of *Setaria glauca*. these data have

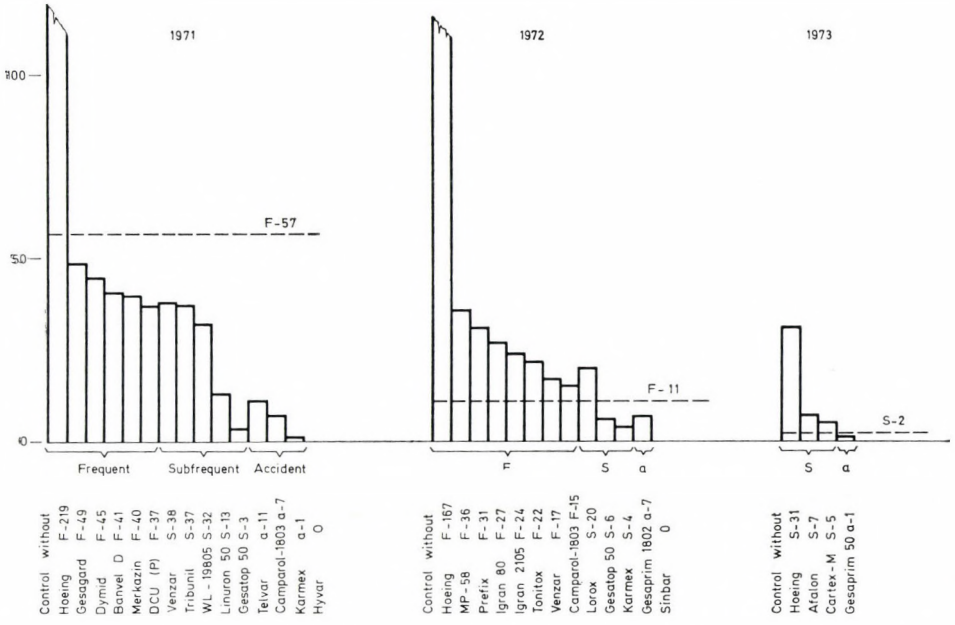


Fig. 2. Herbicides strongly decreasing the frequency of occurrence of *Setaria glauca*

to be controlled with respect to herbicide sensitivity of culture plants and their biological production (seed) too. For this reason it should be remarked that 11 of the *Setaria*-inhibiting preparations from the 29 herbicides listed in Fig. 2. Gesatop 50, Karmex, Venzar and Camparol 803 used in 1971 and 1972 proved to be phytotoxic to both investigated lupin species. For example, Sinbar and Hyvar killed beside the representatives of the *Setaria* species all the weed species in the plots treated with these heterocyclic compounds and the two lupin plants growing in this culture-consociation too.

Among the above mentioned preparations which decreased markedly the number of *Setaria glauca*, 13 inhibited by more than 50% the growth of *Lupinus albus* and 11 the *L. luteus*. Merkazin did not decrease the number of lupin species but it did their seed yield. Linuron 50 compared to the hoed control did not decrease either with respect to number of production of culture plants.

Karmex (diuron) similarly to Linuron 50 proved to be very favourable to *L. albus* and Venzar (lenacil) in *L. luteus* cultures.

As it is evident from these data, among the preparations shown in Fig. 2 from the points of view of production biology and agriculture, mainly the last three could be evaluated positively and for *L. albus* cultures also the linuron-containing preparations Lorox and Afalon and as regards the *L. luteus* cultures Gesagard and Tribunil herbicides could be mentioned.

Table 4

Mass of weeds and the frequency of weed species

Herbicides		Weight of weeds in % of control without hoeing	Number of weeds in % of control without hoeing	Agro-pyron repens	Digitaria sanguinalis	Echinochloa crus-galli	Setaria glauca
Treatments	Chemical groups						
A 2591	XIX-70	63.7	27.5	—	s/ 61	f/ 26	s/ 59
Amine 20%	I-1	107,2	59.2	—	F/ 39	s/ 52	F/245
Amino-Triazole	XXI-82	106.1	73.8	—	s/120	s/ 24	F/200
Amitrol TL	XXI-81	87.6	90.6	—	F/ 73	s/ 76	F/181
Atracil C	XXIII-91	71.0	43.5	—	a/ 15	f/ 18	F/139
Aquatol G	XVII-65	115.5	86.3	—	s/ 22	F/108	F/108
BNP 20	I-3	116.6	94.6	—	s/ 83	s/146	F/265
Banvel D	XXIII-92	139.8	31.9	—	F/ 84	F/101	F/ 41
Bexone	VII-16	104.3	67.0	—	a/ 15	s/ 56	F/138
Camparol 1803	XXIII-93	41.5	16.3	—	F/ 95	s/ 11	a/ 7
Campione	XIII-40	94.1	60.6	—	a/ 12	s/ 86	F/182
Casoron 133	XV-60	111.2	59.7	—	s/ 8	s/ 66	F/170
DCU (F)	XIV-47	85.1	102.3	—	s/ 14	s/ 47	F/264
DCU (P)	XIV-48	72.5	67.7	—	a/ 55	s/ 20	F/ 37
DNBP 20	I-4	93.4	76.9	—	F/157	s/ 47	F/218
Dymid	XI-27	67.7	62.4	—	a/ 2	f/ 15	F/ 45
Dyserbo	VII-17	95.2	122.4	—	s/337	s/ 70	F/157
Embutor	VII-19	102.1	60.3	a/1	a/ 38	s/ 12	F/216
Embutor E	VII-18	110.1	49.5	—	s/ 33	F/ 91	F/176
Gesagard 50	XX-74	81.5	23.7	—	s/ 70	f/ 25	F/ 49
Gesatop 50	XIX-72	33.3	3.6	a/1	f/ 5	s/ 9	s/ 3
Hydrothal	XVII-67	80.0	104.8	—	s/ 46	s/ 54	F/214
Hyvar	XXI-83	0.0	0.0	—	—	—	—
Hoe 2849	XXIII-99	66.6	28.3	—	s/ 57	F/ 71	F/ 57
Hortox	XI-29	77.5	45.9	—	s/ 2	s/ 42	F/178
Karmex	XIV-51	2.5	0.5	—	a/ 1	a/ 2	a/ 1
Kloben	XIV-50	80.0	27.3	—	s/ 30	F/ 60	F/ 66
Krezonit E	I-6	89.1	36.1	—	s/ 10	F/ 31	F/197
Legumex D	VII-20	84.7	56.9	—	s/ 40	s/ 59	F/150
Legumex M	VII-21	111.2	71.3	—	s/ 29	s/ 30	F/194
Lironox	IV-10	111.2	53.7	—	s/ 18	s/ 46	F/165
Linuron 50	XIV-52	24.2	15.2	—	F/ 85	s/ 6	s/ 13
Merkazin	XX-79	52.1	17.7	—	s/ 48	s/ 16	F/ 40
Murbetol	XXIII-101	87.3	101.5	—	s/ 82	s/ 90	F/205
NPH 1254	XV-62	75.7	44.5	—	s/ 21	F/149	F/ 64
NPH 1264	XV-61	104.7	44.6	—	s/ 11	F/142	s/ 63
Ordram	XIII-41	91.6	85.7	—	s/ 33	s/ 48	F/258
Planavin 75	XXII-87	62.3	51.3	—	s/ 13	s/ 60	F/130
Pyramin	XXI-84	65.9	53.2	—	s/ 30	s/ 60	F/145
R-Eptapur	XIV-56	75.3	35.6	—	F/ 78	F/ 38	F/111
Semeron	XX-80	80.4	39.6	—	s/ 64	F/ 53	F/ 77
Stam F 34	XI-34	101.8	82.4	—	F/ 40	F/119	F/240
Sys 67 I	VI-14	92.0	95.5	—	s/ 42	s/ 56	F/205
Sys 67 II	VI-15	66.6	89.5	—	s/ 31	s/ 53	F/253
Telvar	XIV-59	8.5	4.7	—	s/ 15	s/ 5	s/ 11
Tillam 6-E	XIII-42	88.7	87.3	—	s/ 17	s/ 48	F/200
Tribunil	XIV-58	57.2	29.0	—	s/ 22	F/ 51	s/ 37
Tropotox	VII-23	97.8	58.2	—	s/ 10	s/ 45	F/194
Vegiben	ΣIII-24	79.1	76.2	—	F/ 91	F/243	F/106
Venzar	XXI-86	66.8	9.7	—	a/ 2	f/ 26	s/ 38
Vernam	III-44	106.1	99.4	—	s/ 50	s/ 63	F/323
WL-19805	XVIII-68	82.9	13.1	—	F/ 34	f/ 25	s/ 32
Hoed control		16.1	70.5	—	F/403	F/ 41	F/ 57
Control without hoeing		100.0	100.0	—	F/ 97	s/ 32	F/219

altogether: 52 herbicide treatments

affected by herbicides in a lupin culture-consociation 1971

Trifolium arvense	Vicia hirsuta	Convolvulus arvensis	Melandrium album	Chenopodium album	Amaranthus retroflexus	Polygonum aviculare	Polygonum convolvulus	Polygonum lapathifolium	Cannabis sativa
—	—	a/1	—	F/ 41	a/ 1	F/ 8	—	—	—
—	—	—	—	F/ 72	a/ 1	s/13	s/ 2	—	—
—	—	—	a/1	F/113	—	s/18	s/11	a/12	—
—	—	—	a/2	F/293	a/ 8	s/12	a/ 1	a/ 2	—
—	—	—	—	F/105	a/13	s/12	s/ 5	a/ 5	—
—	—	—	—	F/295	—	s/ 8	a/ 3	—	—
—	—	—	—	F/150	a/ 8	F/21	a/ 3	a/ 2	—
—	—	—	—	—	—	—	—	—	—
—	a/1	—	—	F/234	a/15	s/ 8	s/ 7	a/ 6	—
—	—	—	—	a/ 3	—	—	—	a/ 1	—
—	—	—	—	F/131	s/ 2	s/10	s/ 8	s/ 2	a/1
—	—	a/1	—	F/171	—	F/12	—	—	—
—	—	—	a/1	F/381	—	s/21	s/11	a/ 3	a/1
—	—	—	—	F/327	a/ 6	F/39	—	a/ 1	—
—	—	—	—	F/114	a/ 2	s/13	—	—	—
—	—	a/2	—	F/370	a/ 1	s/ 8	s/ 4	—	—
—	—	—	—	F/290	a/ 1	F/ 5	s/15	a/ 1	—
a/1	—	—	—	F/113	a/37	s/ 6	s/ 5	s/ 4	—
—	—	—	—	F/ 47	a/13	s/ 7	s/ 7	—	—
—	—	—	—	f/ 25	a/ 1	—	—	—	—
—	—	—	—	a/ 6	—	s/ 2	—	—	—
—	—	—	—	F/420	—	a/10	s/ 7	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	s/ 2	a/ 1	a/ 3	—	—	—
—	—	a/1	—	F/ 74	a/ 1	s/11	s/19	a/ 1	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	F/ 32	a/ 2	s/16	—	—	—
—	—	—	—	f/ 19	—	—	s/ 2	—	—
a/1	—	—	—	F/130	s/16	s/ 7	s/ 5	—	—
—	—	—	—	F/204	a/ 3	s/15	F/18	s/18	—
—	—	—	—	F/115	a/ 1	F/14	s/ 4	s/ 7	—
—	a/2	—	—	—	—	s/ 2	—	—	—
—	—	—	—	f/ 19	—	a/ 3	—	—	—
a/1	—	—	—	F/327	—	F/18	a/ 3	a/ 1	—
—	—	—	—	F/ 67	a/ 2	s/10	s/ 6	—	—
—	—	—	—	s/ 96	—	s/ 4	s/ 4	—	—
—	—	—	—	F/213	—	F/46	s/16	—	—
a/1	—	—	—	F/138	—	F/10	s/ 5	s/11	—
—	—	—	—	F/144	—	s/ 2	—	—	—
—	—	—	—	f/ 22	a/ 1	F/ 5	—	—	—
—	—	a/2	—	F/ 79	—	s/10	—	—	—
—	—	—	—	F/166	a/ 2	s/20	/02	a/ 1	—
s/2	—	—	—	F/359	s/ 2	s/12	a/ 3	a/ 2	—
—	—	—	—	F/258	a/ 1	s/30	s/11	s/ 4	—
—	a/1	—	—	—	—	—	—	s/ 2	—
—	—	—	—	F/289	—	F/31	s/18	a/ 1	—
—	—	—	—	F/ 84	a/ 5	s/ 7	a/ 1	—	—
—	a/1	—	—	F/141	a/ 1	s/ 2	a/ 3	s/ 2	—
—	—	—	—	s/ 21	s/ 8	F/ 8	s/ 2	—	—
—	—	—	—	a/ 1	s/ 3	—	—	—	—
—	—	—	—	F/248	—	F/22	s/ 6	—	—
—	—	—	—	—	s/ 2	—	a/ 1	—	—
—	—	—	—	s/ 2	—	—	—	a/ 2	—
a/1	—	—	—	F/377	a/ 1	s/13	s/ 5	a/ 1	—

For the control of *Setaria* species to be found in every weed association in Hungary, the Ramrod and Hungazin PK and NaTA + Aresin NaTA + Pyramin combinations mentioned by UBRIZSY and GIMESI (1969) KÁDÁR (1973) refer to the resistance of *Setaria glauca* to 2,4,5, T and tolerance to Hungazin.

In the course of our investigations on sensitivity to *Setaria* species good results were achieved in 1971 with Camparol 1803 (a—7), Gesatop 50 (s—3), Karmex (a—1), Linuron 50 (s—13), in 1972 with Aktikon (—), Gesaprim 1802 (a—7), Gesatop 50 (s—6), Karmex (s—4), Venzar (F—17), in 1973 with Afalon (s—7), Diralid (s—9), Gesaprim 50 (s—1), Cartex M (s—5) but it should be noted that *Setaria glauca* proved to be resistant or tolerant to 74% of the preparations. KÁDÁR (773) mentions resistance of *Digitaria sanguinalis* toward 2,4 D and 2,4,5—T and its tolerance to Hungazin.

The *Digitaria sanguinalis* proved to be sensitive to Dymid (a—2), Hortox (a—2), Karmex (a—2) in 1971, and in 1972 to Dikotex (—), Embutox plus (—), Hoe 2913 (—), Karmex (—), Venzar (—) in 1973 Avadex (a—2), Diralid (s—7), Sys 67 (a—7), and Venzar (s—3) herbicides.

For the control of *Echinochloa* species UBRIZSY and GIMESI (1969) recommended Dalapon, Lasso, Randox, NaTA, Synpram, Hungazin PK and DT, Synpram and Ordram herbicides, while KÁDÁR (1973) mentions the resistance of *Echinochloa crus-galli* to 2,4—D, 2,4,5—T MCPA dinosebacetate and tolerance to Hungazin.

We found that against *Echinochloa crus-galli* in 1971 Karmex (a—2), Linuron 50 (s—6), Gesatop 50 (S—9), Campione (a—12), in 1972. Embutor plus (a—1), Dikotex (a—1), Camparol 1803 (—), Venzar (—) and in 1973 Gesatop 50 (s—7), Ramrod (s—3), Trimetrin (s—6) proved to be effective.

According to the publications of UBRIZSY and GIMESI (1969) and KÁDÁR (1973) among the 12 herbicides, *Chenopodium album* proved to be moderately sensitive to NaTA and Dinosebacetate and to the other 10 investigated preparations it was very sensitive.

In our observations Camparol 1803 (a—3), Hoe 2849 (s—2), Venzar (a—1) Gesatop 50 (a—6) in 1971 and in 1972 A 2591 (—), Camparol 1803 (—), Hoe 2849 (—), Igran 80 (—), Igran 2105 (—), Karmex (—), Venzar (—) and in 1973 Afalon (a—1), Gesaprim 50 (—), Trimetrin (—) and Venzar (—) herbicides proved to be very effective to *Chenopodium album* but it was more or less sensitive to 65% of the tested herbicides.

As it is illustrated in Table 4, Hyvar, Karmex Gesatop 50, Telvar, Venzar WL 19805, Linuron 50, Camparol 1803, Merkazin, Gesagard 50, decreased the number of weeds by 100—75% in 1971 compared to the untreated control.

The following herbicides: Kloben, a-2591, Hoe 2849, Tribunil, Banvel D, R-Eptapur, Krezonit E, Semeron, Atracil C, NPH 1254, NPH 1264, Hortox, Embutor E. reduced the number of the weed species by 75—50. 31 of the

54 herbicides studied -in 1971 decreased the number of weeds by less than 50% and the DCU, Dyserbo, Hydrothal, Murbetol compared to the untreated control did not change their number.

As opposed to this, in 1972 only Aretit decreased the number of weeds by 25%, Dikotex (50%), Raphatox (49%), Embutox plus (49%), Hoe 2849 (45%), Betanal (44%), Liro-Betarex (44%), Hoe (39%), Potablan (39%), Basamid (38%), Hoe 2745 (33%), Hoe 2904 (31%) reduced the weed number to 25—50%. From the herbicides applied in 1972 twelve controlled the weeds by 50—75% but eighteen 75—100%.

The number of weeds was high in both herbicide treatments and the hoed control plots too. The number of weed species did not decrease under chemical or mechanical treatments. This could be explained by the high rainfall in June and July before the mapping at the end of summer (Table 2) which is corroborated with the measurements of weed weights (Fig. 3). When drawing up the map, the number of weeds which had sprouted on the effect of rain and were still growing, were counted too.

On the basis of the measurements of weeds in 1971 (Table 4) the Hyvar, Karmex, Telvar, Linuron 50, Gesatop 50 decreased the phytomass of weeds from 75%—100% and Camparol 1803 from 50—75%. In the case of Merkazin (48%), Tribunil (43%), Planavin (38%), A 2591 (37%), Pyramin (34%)

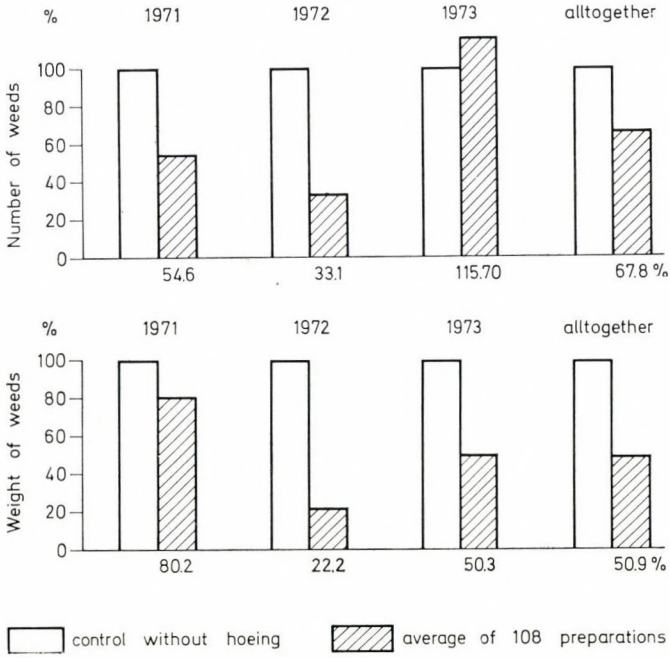


Fig. 3. Summarized effects of herbicides on weeds compared to the control without hoeing

Table 5

Mass of weeds and the frequency of weed species

Herbicides		Weight of weeds in % of control without hoeing	Number of weeds in % of control without hoeing	Digitaria sanguinalis	Echinochloa crus-galli	Setaria glauca
Treatments	Chemical groups					
Aktikon	XIX- 69	0.5	0.7	s/2	—	—
Aretit	I- 2	24.6	77.5	a/4	a/2	F/160
A 2591	XIX- 70	19.2	17.8	—	s/2	F/ 43
Basamid	XIII- 39	16.2	62.0	a/2	--	F/105
Betanal	XII- 35	26.9	56.9	—	s/2	F/104
Camparol 1803	XXIII- 93	21.4	6.2	a/1	—	f/ 15
Chlorflurazole	XXIII- 95	20.0	37.5	a/1	—	F/ 89
Dikotex	V- 11	35.4	50.0	—	a/1	F/112
Embutox plus	XXIII- 96	17.7	51.9	—	a/1	F/124
Etazin 50	XIX- 71	28.0	31.0	s/5	a/1	F/73
Gesaprim 1802	XXIII- 97	2.4	1.5	a/2	—	a/ 7
Gesatop 50	XIX- 72	8.1	3.4	s/3	—	s/ 6
Hoe 2849	XXIII- 99	27.0	55.4	a/2	s/2	F/138
Hoe 2913	XXIV-106	19.6	61.2	—	s/2	F/154
Hoe 2918	XXIV-107	28.0	34.8	a/1	s/2	s/ 62
Hoe 2745	XXIV-108	31.1	63.5	—	a/1	F/142
Hoe 2904	I- 5	21.4	69.7	a/1	a/2	F/152
Hungaria CIPC	XII- 36	12.8	41.0	—	—	F/104
Igran 80	XX- 78	31.1	11.6	—	s/3	f/ 27
Igran 2105	XX- 77	23.4	9.3	—	—	f/ 24
Karmex	XIV- 51	1.0	2.3	—	a/1	s/ 4
Kloben	XIV- 50	20.3	29.0	s/24	s/2	F/ 48
Liro-Betarex	XXIII-100	70.3	56.9	—	s/2	F/141
Lorox	XIV- 53	22.0	9.6	a/4	—	f/ 20
Merkazin	XX- 79	28.7	19.7	a/1	—	F/ 49
M-52	V- 12	30.0	34.1	a/1	a/1	F/ 73
MP-58	VI- 13	21.2	17.0	a/1	a/1	F/ 36
Potablan	XI- 30	25.0	61.2	—	a/9	F/139
Prefix	XV- 63	18.3	13.1	—	—	F/ 31
Prevenol	XII- 37	10.0	45.7	—	a/2	F/109
Raphatox	I- 7	55.3	51.1	a/1	a/1	F/122
Sinbar	XXI- 85	0.0	0.0	—	—	—
Stam F-34-A	XI- 33	20.5	47.2	a/1	s/2	F/113
Tok-E-25	II- 8	18.7	37.9	a/1	s/2	F/ 88
Tonitox	XXIII-102	27.9	10.4	s/4	a/1	f/ 22
Trifenoxin 80	III- 9	32.0	50.0	a/3	s/3	F/117
Tropotox plus	XXIII-104	16.6	22.8	—	—	F/ 80
Venzar	XXI- 86	10.6	7.3	—	—	f/ 17
Hoed control		3.3	4.2	—	—	f/ 11
Control without hoeing		100.0	100.0	—	a/1	F/167

altogether: 38 herbicide treatments

Hoe 2849 (33%), Sys 67 (33%), Venzar (33%), Dymid (32%), Atracil C (29%), DCU (27%) the weed mass was reduced only from 25—50% (but as the values in the brackets indicate here an important reduction in weed plants is entailed).

affected by herbicides in a lupin culture-consociation 1972

Trifolium arvense	Vicia hirsuta	Hibiscus trionum	Convolvulus arvensis	Cirsium arvense	Erigeron acris	Melandrium album	Chenopodium album	Amaranthus retroflexus	Polygonum aviculare	Polygonum convolvulus	Polygonum lapathifolium	Cannabis sativa
—	—	—	—	—	—	—	—	—	—	—	—	—
—	a/32	—	—	—	—	—	s/ 2	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	a/ 1	—	—
—	—	—	a/3	—	—	—	f/ 9	—	—	a/ 1	—	—
a/5	—	—	a/1	a/15	—	—	s/ 6	—	—	s/ 4	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	a/1	—	—	—	a/ 1	—	a/3	a/ 1	a/1	—
—	—	—	s/6	—	—	—	s/ 2	—	—	a/ 1	a/1	a/5
—	—	—	s/4	—	—	—	a/ 1	—	—	s/ 4	—	—
—	a/ 1	—	—	—	—	—	—	—	—	—	—	—
—	a/ 1	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	a/ 1	—	—
—	—	—	—	—	a/2	—	—	—	—	—	—	—
—	—	—	—	—	—	—	a/25	—	—	—	—	—
—	—	—	s/1	—	—	—	f/13	—	—	s/ 5	a/1	a/1
—	—	—	s/2	—	—	—	s/13	—	—	—	a/5	a/5
—	—	—	—	—	—	—	s/ 2	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	a/ 1	—	—	—	—	—	—	—	—	—	—	—
a/1	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	s/3	—	—	—	a/ 1	—	—	—	—	—
—	—	—	—	—	—	a/1	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	a/ 1	—	—
—	—	—	s/4	—	—	—	s/ 7	—	—	a/ 1	a/1	—
—	—	—	s/2	—	—	—	a/ 1	—	—	—	—	s/3
—	—	—	s/3	—	—	—	s/ 7	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	s/ 3	—	—
—	—	—	—	—	—	a/1	s/ 4	a/ 1	—	—	—	a/1
—	—	—	a/1	—	—	—	s/ 4	a/ 1	—	a/ 1	—	a/1
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	a/2	—	—	—	s/ 3	—	—	a/ 1	—	—
a/1	—	—	s/2	—	—	—	a/ 2	—	—	a/ 1	—	a/1
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	a/1	—	—	—	—	—	—	s/ 4	a/1	—
—	s/ 3	—	s/3	—	—	—	s/10	s/10	—	s/ 2	—	—
—	a/ 1	—	—	—	—	—	—	—	—	a/ 1	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	a/10	s/2	a/ 6	a/4	—	s/ 5	s/ 5	—	s/36	—	a/1

The herbicide treatments applied in 1972 were much more favourable for the culture plants (Table 5), namely 24 of the 42 herbicides depressed the weight of weeds by 75—100%. Betanal (73%, Hoe 2849 (73%), Tonitox (73%), Etazin 50 (72%), Hoe 2918 (72%), Merkazin (71%), M 52 (70%), Hoe 2745 (69%), Igran 80 (69%), Trifenox 80 (68%) and Dikotex (64%)

Table 6

Mass of weeds and the frequency of weed species

Herbicides		Weight of weeds in % of control without hoeing	Number of weeds in % of control without hoeing	Equisetum arvense	Digitaria sanguinalis	Echinochloa crus-galli	Setaria glauca
Treatments	Chemical groups						
Afalon	XIV- 45	26.2	105.0	—	s/32	F/44	s/ 7
Aniten D	XXIII- 89	45.0	176.2	a/1	s/23	F/81	s/34
Aniten M	XXIII- 90	26.8	113.7	—	f/19	s/10	F/49
Avadex	XIII- 38	43.5	130.0	—	a/ 2	F/50	s/33
Banlen plus	XXIV-105	53.0	183.7	—	s/29	F/40	F/71
Cartex M	XXIII- 94	30.5	121.2	—	s/20	F/65	s/ 5
Cotoran	XIV- 46	31.4	121.2	—	s/45	s/21	s/29
Dachtal	XVI- 64	42.2	167.5	—	F/49	f/27	F/46
DCPA	XI- 28	69.1	173.7	—	s/17	F/96	s/22
Diralid	XIV- 49	76.5	65.0	—	s/ 7	S/18	s/ 9
Endothal	XVII- 66	55.8	143.7	—	s/10	s/22	F/67
Gesapax 50	XX- 75	49.6	73.7	—	s/26	f/ 7	f/16
Gesaprim 50	XIX- 73	23.1	85.0	—	F/41	s/14	a/ 1
Gesatop 50	XIX- 72	25.6	78.7	—	S/20	s/ 7	s/18
Gesaran	XXIII- 98	43.5	96.2	—	F/59	s/29	f/23
Igran 50	XX- 76	67.2	148.7	—	s/46	s/31	F/38
Legurame	X- 26	76.8	206.2	—	s/38	f/23	F/94
Maloran	XIV- 54	28.3	140.0	—	F/72	s/26	s/11
Na Ta	IX- 25	85.4	116.2	—	s/38	s/29	s/20
Patoran	XIV- 55	29.6	77.5	—	f/27	s/16	s/13
Planavin 75	XXII- 87	125.0	112.5	—	s/50	s/16	s/16
Ramrod	XI- 31	42.9	66.2	—	f/21	s/ 3	f/21
Satecid	XI- 32	104.0	98.7	a/1	s/12	s/23	s/25
Sys 67/B	VII- 22	79.0	115.0	—	a/ 7	F/54	s/23
Tenoran	XIV- 57	49.0	112.5	—	s/13	s/36	s/26
Treflan	XXII- 88	34.8	110.0	—	F/41	s/10	s/21
Trimetrin	XXIII-103	19.7	76.2	—	F/45	s/ 6	s/10
Vegadex	XIII- 43	43.2	87.5	—	s/33	F/45	s/27
Venzar	XXI- 86	31.1	53.7	—	s/ 3	s/17	f/23
Hoed control		16.3	73.7	—	s/21	s/12	s/ 2
Control without hoeing		100.0	100.0	—	f/18	f/25	s/31

altogether: 28 herbicide treatments

reduced the weed mass by 50—75%. But even Raphatox (45%) and Liro-Betarex (30%) resulted in a notable reduction in weight.

In 1973 (Table 6) Trimetrin (80%) and Gesaprim 50 (77%) were prominent with their excellent weed-mass-reducing effect, but the treatments of Gesatop 50, Afalon, Aniten M, Maloran, Patoran, Cartex M, Venzar, Cotoran, Treflan, Dacthal, Ramrod, Vegadex, Avadex, Gesaran, Aniten D, Tenoran, Gesapax 50, in fact Banlene plus, Endothal, Igran 50, DCPA treatments which decreased the weight of weeds from 50—75% were very remarkable. However, the DCU-Diralid 24%, Legurame 24% Sys 67/B 21% NaTA 15% reducing effects should not be ommitted. In this year only Satecid and Planavin 75 proved to be inactive herbicides.

affected by herbicides in a lupin culture-consociation 1973

Vicia hirsuta	Hibiscus trionum	Lamium purpureum	Sinapis arvensis	Erigeron acris	Chenopodium album	Amaranthus retroflexus	Polygonum aviculare	Polygonum convolvulus	Polygonum lapathifolium
—	—	—	—	—	a/ 1	—	—	—	—
—	—	—	—	—	s/ 2	—	—	—	—
—	—	—	—	—	s/ 7	a/2	F/4	—	—
—	—	—	a/1	—	s/16	a/1	—	a/1	—
—	—	—	—	—	s/ 5	—	s/2	—	—
—	—	—	—	—	s/ 4	—	s/3	—	—
—	—	—	—	a/1	a/ 1	—	—	—	—
—	s/2	—	a/1	—	s/ 8	a/1	—	—	—
—	a/1	—	—	—	s/ 3	—		—	—
—	—	—	—	—	s/15	—	s/3	—	—
—	—	—	—	—	f/14	—	s/2	—	—
—	—	—	—	—	s/ 8	—	—	s/2	—
a/2	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	a/1	—	—
—	—	—	—	—	s/ 5	—	a/1	—	—
—	—	—	—	—	s/ 3	—	—	—	a/1
—	—	—	—	—	f/ 9	—	a/1	—	—
—	—	—	—	—	s/ 3	—	—	—	—
—	—	—	—	—	f/ 6	—	—	—	—
—	—	a/1	—	—	s/ 5	—	—	—	—
—	—	—	—	—	s/ 8	—	—	—	—
—	—	—	—	—	s/ 7	—	a/1	—	—
a/1	—	—	—	—	f/13	—	s/3	a/1	—
—	—	—	—	a/1	s/ 7	—	—	—	—
—	a/1	—	—	a/1	s/ 2	—	a/1	—	—
—	—	—	—	a/1	s/ 3	—	s/2	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	s/ 5	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	a/1	s/ 2	—	—	—	—
—	—	—	—	a/1	f/ 5	—	—	—	—

Figure 3 illustrates the mean values of the effect of the applied 108 herbicides on the number of weed species and their biological production compared with the unhoed control. Though the mean values represented the results of herbicides with extensive spectrums it is demonstrated by the columns of Fig. 5 that the herbicide treatments considerably decreased the number of the weeds and their weight too. The only exception in 1973 was the high number of weeds as a consequence of the tremendous rainfall which was discussed earlier. This fact which was explained with the new sprouting of weeds in July is verified by the relatively small amount of weeds in 1973. Generally, more than one third, 42 of the investigated herbicides showed more than 50% reducing effect as regards the number of weeds and their weight decreased to the same extent by more than half (56) in the 108 preparations.

These reinforce our point of view expressed earlier (KECSKÉS—ELEK—BORBÉLY—BORBÉLY 1972/a) that beside registering the number of weeds the individual number of weed species, it is absolutely necessary to measure the weight of the weed phytomass too, because only in this way is it possible to survey and evaluate properly the increasing or decreasing effect of herbicides on the biological production of culture plants and their reducing effect on the weed phytomass.

The preparations were evaluated separately already with the aid of the data of Table 4, 5 and 6 and other results on the biological production of *Lupinus* species (KECSKÉS—ELEK—BORBÉLY, I. and BORBÉLY, F. 1972a) When such a large number of pesticides is applied, it is worthwhile to compare the different chemical groups containing nearly the same number of preparations on the basis of the effect on the culture and weed species. Although the data of three different years is given, we may be able to obtain useful information on the groups having the same or similar active ingredients.

From Figs 4 and 5 it is apparent that from the two species belonging to the same genus, the *L. albus* was less sensitive to the investigated herbicides We have already discussed the deviating sensitivity of the two species to the same herbicides (BORBÉLY, J.—BORBÉLY, F.—ELEK—KECSKÉS, 1972) KECSKÉS—BORBÉLY, J.—BORBÉLY F.—KECSKÉS, M. 1975).

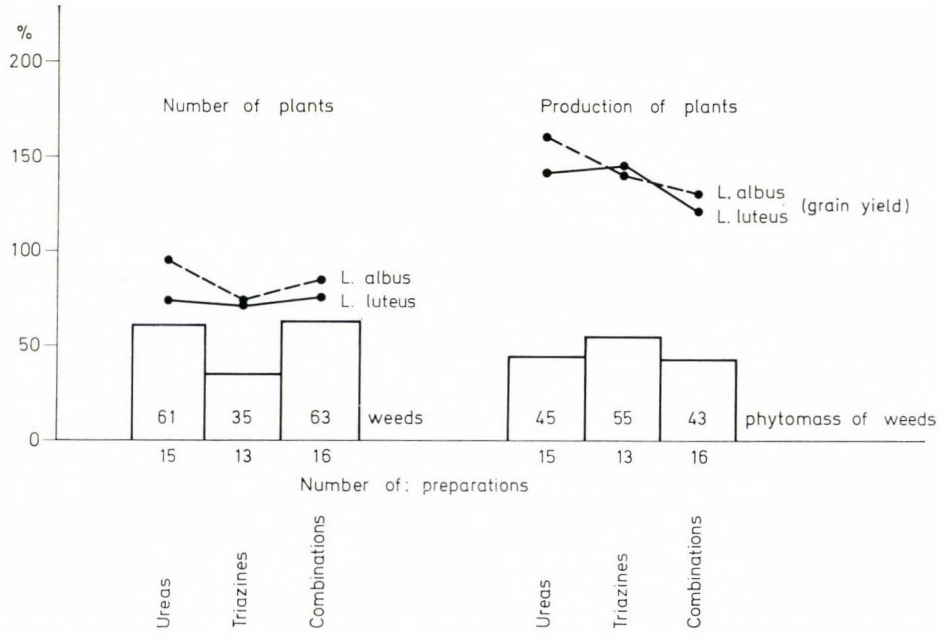


Fig. 4. Lupin biological production and weed control effect of different chemical groups of herbicides I. (Average of preparations in % of control without hoeing)

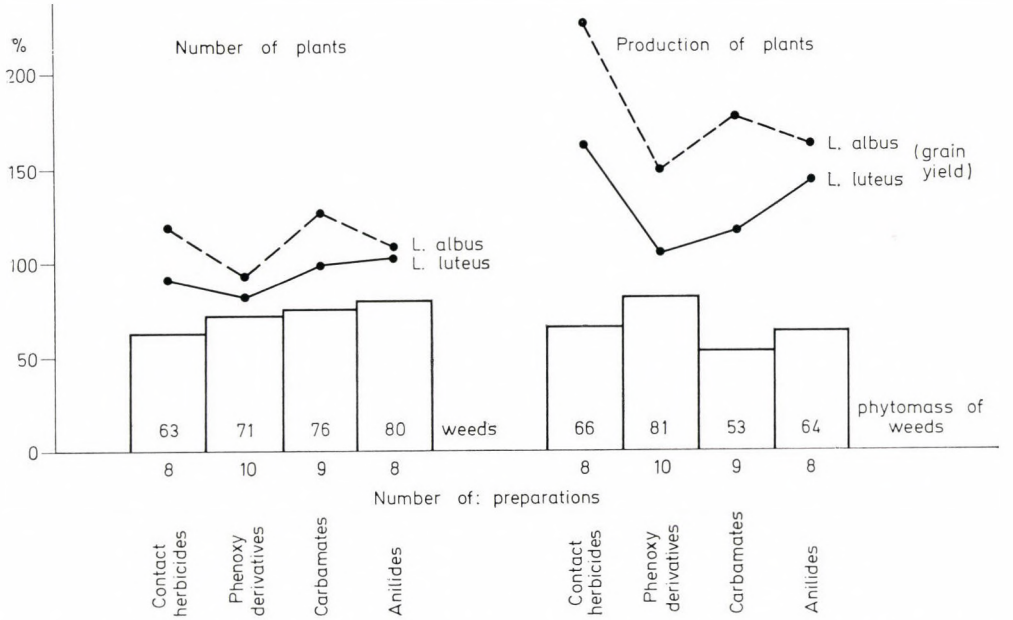


Fig. 5. Lupin biological production and weed control effect of different chemical groups of herbicides II. (Average of preparations in % of control without hoeing)

Comparing carbamide and triazine derivatives and herbicide combinations (Fig. 4) gave almost the same results with respect to the number and weight of weeds. Perhaps only the higher decreasing effect of triazines on the number of weeds could be mentioned.

As regards the culture plants, it seems that both from a sensitivity (individual number) and biological production (seed) points of view generally the carbamide derivatives are more favourable for *L. albus* and the triazine- rather to *L. luteus*. Comparing these groups with the herbicide combinations having more different active ingredients and to a small extent containing active ingredients of both mentioned groups some decreasing effect of the combinations was observed. As it can be seen the combinations (containing generally two, but in one case three herbicide components) in the applied doses and soil types and the given experimental conditions did not prove to be better, than the herbicides with single active ingredients either in increasing the culture plant production or in the weed phytomass-decreasing effect.

As it is well-known nowadays the tendency in the chemicalization of agricultural practice is to form well-selected 3, 4, 5 active ingredients containing herbicide combinations having a synergetic effect. In our investigations we tested only 15% combinations and mainly 85% herbicides containing only one active ingredient because we wanted to study the effect of the individual preparations to obtain detailed and isolated data on single herbicides

for the further selection and right choice of suitable combinations for lupin cultures.

Analysing the data of Fig. 5, the decreasing tendency of the phenoxy derivatives and their phytotoxicity to the culture plants becomes evident. As regards the weed control effect, the contact herbicides consisting of more different chemical groups proved to be relatively good, but the comparison of their effect on some groups of systemic herbicides is not realistic because of their small number (8, 10). This concerns the general evaluation of the carbamates which seems to be favourable for *L. albus* and anilides for *L. luteus*.

It has to be stressed that beyond these general observations and principal statements the individual assessment of the effects and applicability of the single herbicides) including the combinations too) means a decided progress in this problem from a practical point of view too.

Mainly Linuron 50 and the linuron containing Afalon and the A 2591 proved to be promising for both *Lupinus* species, Karmex for *L. albus* and Venzar (lenacil) and one combination Camparol 1803 (prometryne + simazine) of the 108 herbicide preparations investigated by us in a selection experimental series.

This does not mean that quite a lot of the studied herbicides would not be utilizable in the lupin culture-ecosystems formed on the slightly acid brown forest soil of the main lupin-growing area of Hungary (Nyirség) or in other places inspite of their great sensitivity to herbicides or in other places reported by many authors (BORBÉLY and KECSKÉS 1972).

ACKNOWLEDGEMENTS

The experiments were supported by the Protein Programme Technical Development Committee of Hungary for which thanks are due, for the general laboratory soil investigations to Mrs. TATÁR.

REFERENCES

ASZÓD, L. (1935): Adatok a nyírségi homoki vegetáció ökológiájához és szociológiájához (Data on ecology and sociology of sandy vegetation of Nyírség). Tisia, Debrecen **1,** 1—33.

BALÁZS, F. (1944): Növényszociológiai felvételek készítésének újabb módja (Eine neue Methode Zur Herstellung phlanzephysiologischer Aufnahmen) Bot. Közl. **41,** 18—33.

BALÁZS, F. (1948): A gyepek termésbecslése növényszociológiai felvételek alapján (Valuation of grassy land by means of plant-sociological studies). 26—34.

BALÁZS, F. (1949): Magyarország gyomnövényeinek életformaanalízise (Life form analysis of weeds of Hungary). Agrártud. **1,** 109—118.

BALÁZS, F. (1952): Összehasonlító vegeáció tanulmányok évelő pillangós kaszálókon (Comparative vegetation studies of perennial papilionaceous meadows). Mosonmagyaróvári Mezőgazd. Kis. Int. Évk. 63—73.

BODROGKÖZY, Gy. (1959): Adatok a délkeletkiskunsági homoki szőlők gyomtársulásainak ismeretéhez (Beiträge zur Kenntnis der Unkrautassoziationen in Weingärten auf Sandböden im südöstlichen Teile des Kiskunság) Bot. Közl. **48,** 81—94.

BORBÉLY, I.—BORBÉLY, F.—ELEK, É.—KECSKÉS, M. ((1972): Vegyszeres gyomirtási problémák a csillagfürt termesztésében. A mezőgazdaság kemizálása (Problems of chemical weed control in the growing of lupin. Chemicalization of the agriculture). NEVIKI-KAE. Veszprém—Keszthely. *II*, 47—50.

BORBÉLY, I.—BORBÉLY, F.—ELEK, É.—KECSKÉS, M. (1973): További vizsgálatok csillagfürt kultúrák vegyszeres gyomirtására. A mezőgazdaság kemizálása (Further investigation of the chemical weed killing for lupin cultures. Chemicalization of the agriculture). NEVIKI-KAE Veszprém—Keszthely. *II*, 115—119.

BORBÉLY, I.—BORBÉLY, F.—ELEK, É.—KECSKÉS, M. (1974): A gyomirtószerek hatásának vizsgálata a csillagfürttel szimbiózisban élő rhizobiumok fejlődésére. Az 1973. évi Környezetvédelmi Kutatási Eredmények (The examination of the effect of herbicides on the development of rhizobia living in symbiosis with lupin. Results of the Biosphere research of 1973.) Mezőgazdasági és Élelmezési Minisztérium. Budapest. 48—53.

BORBÉLY, I.—KECSKÉS, M.(1972): The influence of ureas and S-triazines on rhizobia and grain yield of Lupinus luteus L. Symp. Biol. Hung. **11,** 427—445.

BORHIDI, A. (1961): Klimadiagramme und klimazonale Karte Ungarns. Ann. Univ. Bp. Sect. Biol. **4,** 21—50.

ELEK, É.—BORBÉLY, I.—BORBÉLY, F.—KECSKÉS, M. (1973): A pillangósok fehérje tartalmát növelő herbicidek vizsgálata (Investigation on the herbicides increasing the protein content of legumes). Agrártudományi Közlemények **33,** 33—39.

ELEK, É.—BORBÉLY, I.—BORBÉLY, F.—KECSKÉS, M. (1974): Herbicides increasing the protein content of lupin. Acta Agronomica Academiae Scientarum Hungaricae **23,** 456—459.

FEKETE, G. (1975): Interspecifikus kapcsolatok, kölcsönhatások és az ökológiai niche elemzése tölgy erdei fajokon (Interspecific connections, interactions and the analysis of the ecological niche on species of an oakwood). D. Sc. Thesis, pp. 14, Budapest,

FELFÖLDY, L. (1942): Szociológiai vizsgálatok a pannóniai flóraterület gyomvegetációján (Soziologische Untersuchungen über die pannonische Ruderalvegetation). Acta Geobot. Hung. **5,** 87—138.

FREYER, J. D.—EVANS, S. A. (eds) (1968): Weed Control Handbook. Blackwell Scientific Publ., Oxford and Edinburgh, 846. pp.

GIMESI, A. (1964): Chemische Unkrautbekämpfung in Luzerne. Nachr. Stsch. Pflsch. Dienst. **3,** 65—67.

GIMESI, A. (1965): Vegyszeres gyomirtás hüvelyesekben (Chemical weed control in legume cultures). Magyar Mezőgazdaság **22,** 14—15.

GIMESI, A. (1969): Neue Erfahrungen mit der chemischen Unkrautbekämpfung und Defoliation in Luzerne. Och. Rostlin Praha. **5,** 31—38.

GIMESI, A. (1971): Chemische Selektion in Samenbeständen von Futterleguminosen. Weed Research. **11,** 204—206.

GIMESI, A. (1972): Új eredmények a lucerna kémiai gyomirtásában. Növényterm. **21,** 63—70.

GIMESI, A. (1975): Trifolium fajok kémiai gyomirtási kísérleteinek eredményei (Results of chemical weed control experiments in Trifolium species). Növénytermelés **24,** 133—138.

GIMESI, A.—UBRIZSY, G. (1964): Vegyszeres gyomirtás a pillangós takarmánynövényekben (Weed control in the leguminous fodder crops). Mezőgazd. Világirod. **5,** 15—19.

GIMESI, A.—UBRIZSY, G. (1971): Újabb eredmények a termesztett hüvelyes növények hazai vegyszeres gyomirtásában (Recent results in the chemical weed control of legume crops in Hungary). Takarmánybázis. **11,** 9—23.

GONDOLA, I. (1964): Cönológiai vizsgálatok a nyírségi laza homoktalajok rozs- és csillagfürt vetéseinek gyomnövénytársulásán (Zönologische Untersuchungen über der Unkrautgesellschaften bei Anbau von Roggen und Lupinen auf lockerem Sandboden im Gebiet Nyírség). Debreceni Agrártud. Főisk. Tud. Közl. **10,** 143—156.

GONDOLA, I.: Adatok a szántóföldi gyomnövénytársulások edafikus és mikrorelief viszonyaihog való alkalmazkodására a Nyírségben (Angaben über die Anpassung der Ackerunkrautgesellschaften an die edaphischen und Mikrorelief-Verhältnisse im Gebiet Nyírség). Debreceni Agrártud. Főisk. Tud. Közt. **12,** 41—56.

GONDOLA, J. (1969): Florisztikai adatok a Nyírség és környéke szántóföldjeiről (Floristische Angaben über die Ackerfelder des Nyírség und Umgebung). Bot. Közl. **56,** 167—173.

HARPER, J. L. (1957): Ecological Aspects of Weed Control. Outlook on Agric. Berkshire, **5,** 197—205.

JEANPLONG, J. (1951): Adatok és összehasonlító vizsgálatok Nyugat-Magyarország szántóföldi gyomviszonyainak ismeretéhez. Agrártud. Egyet. Mezőgazd. Tud. Kar. Évk. **2,** 17—38.

JEANPLONG, J. (1955): Évelő pillangósok gyomcönológiai viszonyai Szombathely környékén Agrártud. Egyet. Agron. Kar. Kiadv. **2,** 1—23.

KÁDÁR, A. (1973): A gyomirtószerek gyakorlati felhasználása (Practical use of herbicides). In: ÚJVÁROSI, M.: Gyomirtás ;Weed control). 197—268. Mezőgazdasági Kiadó, Budapest.

KECSKÉS, M.—BORBÉLY, I.—BORBÉLY, F.—ELEK, É. (1972): Selective investigations on herbicides not inhibiting rhizobia-lupin symbiosis. Symposium on "The effect of chemicalization in agriculture on microbiological processes in the soil". Sofia, Papers of Scientific Conference, Pushakarov Inst. of Soil Sci. Sofia, 64—67.

KECSKÉS, M.—BORBÉLY, I.—BORBÉLY, F.—ELEK, É.: (1975): Herbicide sensitivity of Lupinus and Rhizobium species. Roczniki Glebozmawce, **26,** 137—143.

KECSKÉS, M.—ELEK, É.—BORBÉLY, I.—BORBÉLY, F. (1972): Herbicidek hatása a csillagfürt-rhizobium szimbiózisára. A MTA Elnöksége által az országos és tárcaszintű kutatási főirányok körében kiírt pályázaton díjat nyert munka (The effect of herbicides on the lupin-rhizobium symbiosis. Prizewinning work in the competition from the main research trends at national and ministerial level published by the President of the Hungarian Academy of Sciences, pp. 50). Akadémiai Közlöny (1973), **12,** 1, 12.

KECSKÉS, M.—ELEK, É.—BORBÉLY, I.—BORBÉLY, F. (1972a): Herbicidek csillagfürt-rhizobium szimbiózisra gyakorolt hatásának laboratóriumi és szabadföldi vizsgálata (Laboratory and field investigations on lupin-rhizobium symbiosis affected by herbicides). Agrártudományi Közlemények **31,** 343—359.

KECSKÉS, M.—ELEK, É.—BORBÉLY, I.—BORBÉLY, F. (1973): Herbicides and Rhizobium-lupin symbiosis. Rhizobium Newletter **18,** 74—75.

MÁTHÉ, J.—PRÉCSÉNYI, I. (1968): Adatok egy búzatábla fitomassza produkciójához. (Angaben über die Phytomassenproduktion auf einem Weizenfeld). Agrártudományi Közl. **27,** 253—264.

MÁTHÉ, J.—PRÉCSÉNYI, I. (1971): Újabb adatok az Újszentmargitai IBP mintaterület szántóföldjének primér produkciójához (Newer data on the primer production of arable fields of the IBP sample area of Újszentmargita). Agrártud. Közl. **30,** 450—463.

RAYNAUD, G. (1971): Désherbage des céréales: Une conception nouvelle. Paysan, Cognac, **44,** 15—17.

SOÓ, R. (1933): A Nyírség vegetációjának ismeretéhez (Data on the vegetation of Nyírség). Debreceni Szemle **7,** 251—256.

SOÓ, R. (1934): Nyírség-kutatásunk florisztikai eredményei (Die floristischen Ergebnisse der Erforschung des Nyírség). Bot. Közl. **31,** 218—252.

SOÓ, R. (1938): A Nyírség vegetációja II. A Nyírség vízi, mocsári és réti növényszövetkezetei (Die Vegetation des Sandgebiets Nyírség II. Wiesenpflanzengesellschaften (Herbosa). Mat. és Természettud. Ért. **57,** 897—910.

SOÓ, R. (1939): A Nyírség vegetációja III. A Nyírség pusztai növényszövetkezetei (Die floristischen Ergebnisse der Erforschung des Nyírség III. Die Steppenpflanzengesellschaften, Deserta). MTA Mat. és Természettud. Ért, **58,** 833—844.

SOÓ, R. (1964—1973): A magyar flóra és vegetáció rendszertani és növényföldrajzi Kézikönyve. (Systematical and geobotanical handbook of the Hungarian flora and vegetation). **I—V,** Akadémiai Kiadó, Budapest.

TIMÁR, L. (1954): Ackerunkrauter auf alkalischen Lößboden in Umgebung von Szeged. Acta Botanica Acad. Sci. Hung. **1,** 193—214.

TIMÁR, L.—UBRIZSY, G (1957): Die Ackerunkräuter Ungarns mit besonderer Rücksicht auf die chemische Unkrautbekämpfung. Acta Agron. Acad. Sci. Hung. **7,** 123—155.

UBRIZSY, G. (1950): Les associations des mauvaises herbes ruderales de la Hongrie et les aspects agricoles du problème. Acta Agron. **1,** 107—159, in Hungarian: Mezőgazd. Tud. Közl. **1,** 86—123.

UBRIZSY, G. (1955): Magyarország ruderális gyomnövénytársulásai II. Ökológiai és szukcesszió tanulmányok (Ruderal weed associations in Hungary. II. Studies on Ecology and Succession.) Növénytermelés **4,** 109—126.

UBRIZSY, G. (ed.), (1968): Növényvédelmi enciklopédia (Encyclopedy of Plant Protection) *I*, pp. 486. Mezőgazdasági Kiadó, Budapest.

UBRIZSY, G. (1960): A kukoricában végzett vegyszeres gyomirtás a herbicid hatás tükrében (Die Unkrautbekämpfung in Maiskulturen im Spiegel der Herbizidwirkung) MTA IV Oszt. Közl. **17,** 51—75.

UBRIZSY, G. (1962): Vegyszeres gyomirtás szója-paszuly- és csillagfürt-vetésekben (Chemical weed control in soybean, bean and lupin crops). A Növényvédelem Időszerű Kérdései. Mezőgazdasági Kiadó, Budapest, **2,** 20—26.

UBRIZSY, G.—GIMESI, A. (1969): A vegyszeres gyomirtás gyakorlata (Practice of the chemical weed control). 310. pp. Budapest. Mezőgazd. Kiadó.

ÚJVÁROSI, M. (1952): Szántóföldjeink gyomnövényfajai és életformaanalízisük (Weed of our arable fields and analysis of their life forms). Növénytermesztés **1,** 27—50.

ÚJVÁROSI, M. (1955): Hozzászólás SIPOS, G.: A gyomirtás kérdése a mezőgazdaságban (Comment to G. SIPOS: Problem of weed control in the agriculture) MTA IV. Oszt. Közl. **8,** 246—248.
ÚJVÁROSI, M. (1957): Gyomnövények, gyomirtás (Weeds, weed control). 787. pp. Mezőgazdasági Kiadó, Budapest.
ÚJVÁROSI, M. (1973): Gyomnövények (Weed plants). pp. 833. Mezőgazdasági Kiadó, Budapest.
ÚJVÁROSI, M. (1973): Gyomirtás (Weed Control). Mezőgazdasági Kiadó, Budapest, pp. 288.
VAN DER ZWEEP, W. (1971): Les conséquences du désherbage moderne pour les techniques de la production agricole. Phytoma, Paris **23,** 27—32.
VORSATZ, E. (1963): Herbicide—chemisch und praktisch gesehen. Wiss. Z. F. Schiller Univ. Mat-Nat. Wiss. Reihe, Jena **12,** 83—85.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (3—4), pp. 295—320 (1976)

PLANTAS NUEVAS EN CUBA V.

Por

A. Borhidi

JARDIN BOTANICO DE LA EÖTVÖS UNIVERSIDAD, BUDAPEST, HUNGRIA

y

O. Muñiz

INSTITUTO DE BOTANICA DE LA ACADEMIA DE CIENCIAS DE CUBA, LA HABANA

(Received November 3, 1976)

The present study is the fifth continuation of the series "New plants in Cuba I—IV.", and contains the descriptions of 44 new taxa and revisions of some polymorphic or critical species. The new taxa are: *Orchidaceae: Epidendrum* (1 sp.); *Piperaceae: Piper* (1 sp.); *Polygonaceae: Coccoloba* (1 sp., 1 var.); *Mimosaceae: Pithecellobium* (1 ssp.); *Caesalpiniaceae: Cassia* (2 sp.), *Caesalpinia* (1 ssp.); *Fabaceae: Brya* (1 sp.); *Erythroxylaceae: Erythroxylon* (4 sp.); *Rutaceae: Ravenia* (1 sp.); *Euphorbiaceae: Acidocroton* (1 sp.), *Moacroton* (1 var.), *Bonania* (2 sp.); *Buxaceae: Buxus* (2 sp.); *Aquifoliaceae: Ilex* (1 sp.); *Celastraceae: Crossopetalum* (1 sp.); *Sapindaceae: Thouinia* (2 sp.); *Rhamnaceae: Rhamnidium* (1 sp.), *Karwinskia* (1 sp.); *Clusiaceae: Rheedia* (2 sp., 1 var.); *Flacourtiaceae: Samyda* (2 sp.); *Thymelaeaceae: Daphnopsis* (1 var.); *Symplocaceae: Symplocos* (1 sp.); *Borraginaceae: Cordia* (2 sp.); *Verbenaceae: Callicarpa* (2 sp.), *Vitex* (3 sp.); *Solanaceae: Cestrum* (1 sp., 1 var.); *Gesneriaceae: Gesneria* (2 sp.) Taxonomic revision of the following species is contributed: *Coccoloba coriacea, Pithecellobium asplenifolium, Caesalpinia bahamensis, Rheedia fruticosa* s.l. and *R. ruscifolia* with a new analytic key for the Cuban species of the genus *Rheedia.*

Fam.: **Orchidaceae**

Epidendrum cubincola Borhidi sp. nova

(**E. polybulbon** auct. cub. non Sw.)

Planta epiphytica, procumbens, rhizoma plerumque ramificata et longe reptans, radicibus elongatis, flexuosis glabrisve. Pseudobulbi suborbiculares, vel breviter elliptici, 5—10 mm. longi et 4—7 mm. lati, in sicco valde plicati, bifoliati, vaginis mox fibrose dissolutis primum obtecti. Folia patentia, suborbicularia, elliptica vel late ovata basi breviter angustata, antice rotundata et profunde excisa et breviter mucronulata, 0.7—1.5 cm. longa et 0.5—0.8 cm. lata, nervis parallelibus longitudinalibusque numerosis utrinque prominentibus margine integra subcoriacea. Flores terminales solitarii. Bracteae 3, ovato-lanceolatae, apice acuminatae et subulatae, 5—7 mm. longae et 3—5 mm. latae, ovario 2—3-plo breviores. Flos 2—3 cm. longus, sepala oblongo-lanceolata vel lineari-lanceolata, apice acuta et breviter apiculata, purpureo-brunnea vel brunneo-violacea, apice flava, 0.8—1.4 cm. longa et 1.5—2.5 mm. lata, petala linearia vel anguste lineari-oblanceolata, sepalis ± aequilonga, 0.7—1.5 mm. lata, apice acuta, colore simillima. Labelli unguis 3—4 mm. longus, marginibus columnae brevissime adnatus, lamina orbicularia, 5—8 mm. longa et lata, margine integra et undulata, columna semiteres glabra, 3—4 mm. longa, auriculis juxta stigma bene evolutis, triangulo-subulatis 2—3 mm. longis, apice breviter bilobulatis suffulta. Ovarium glabrum 1.2—2 cm. longum.

Holotypus: Acuña 21104; Prov. Oriente; Sierra Maestra: Gran Piedra, Santiago de Cuba; Leg.: Acuña, Pino y Alonso 26. Sept. 1959. SV!

Specim. exam.: Gran Piedra in pluviisilvis montanis alt. cca. 1200 m.s.m. Leg. A. BORHIDI et O. MUÑIZ 25. Oct. 1969! — Sierra del Cristal, bosque humedo en la subida del Pico del Cristal, Leg. ALAIN, ACUÑA et M. LÓPEZ-FIGUEIRAS 5656! 2—7. Apr. 1956. — Cuchillas de Toa; Bajada del Rio Peña, desde los charrascos de Peña Prieta, La Magdalena, Toa, alt. 600 m. s.m. Leg.: ALAIN 3866! 30. Dec. 1953.

Obs.: *E. polybulboni* Sw. (e Jamaica) affinis, quod pseudobulbis oblongo-ovatis, 2—3 cm. longis, foliis oblongo-ellipticis vel oblongo-ovatis, 3—6 cm. longis et 0,6—1,0 cm. latis, bracteis longioribus, floribus 3—4,5 cm. longis, sepalis 1,5—2 cm. longis, pallide flavis, sepalis aequalibus albis, labello 2—4 mm. longe unguiculato, lamina ipsa late ovata, basi truncata, 1—1,2 cm. longa et lata, alba, ovario cum pedicello 2—2,5 cm. longo sine dubio specifice differt.

Fam.: **Piperaceae**

Piper guanahacabibense Borhidi sp. nova

Frutex ramosissimus, 2—3 m. altus. Ramuli hornotini 4-angulati, striati, nigrescentes, vetustiores costulati, lenticellis prominentibus ± dense obtecti, cortice eburnei vel albi, glabri, ad nodos articulati. Folia 1—2 mm. longe petiolata, elliptica, apice rotundata, basi brevissime obtusa vel rotundata, 1,8—4 cm. longa, 1—2 cm. lata, 3-nervia vel basi obsolete 5-nervia, nervis principalibus supra leviter impressis vel obsoletis, subtus tenuiter prominentibus, transversalibus supra inconspicuis, subtus obscure prominulo-reticulatis, utrinque glaberrima supra olivacea vel brunnescentia, subtus brunnescentia vel cinerea, minutissime pellucido-punctata, chartacea. Spicae terminales 2—5 cm. longae, pedunculi 0,5—1 cm. longi, rhachis angulata, dense et minute albo- vel pallide ferrugineo-pulverulenta, 0,5 mm. crassa. Flores 0,2—0,5 mm. longe pedicellati, pulverulenti; stigmata 3(—4), late obovata, horizontaliter elata, pulverulenta; bacca ovata, 2 mm. longa, pulverulenta.

Holotypus: BORHIDI 27753 SV!;, Cuba; Prov. Pinar del Rio, Peninsula de Guanahacabibes; in fruticetis saxosis calcareis aridis ad Punta Holandés. Leg.: A. BORHIDI, R. CAPOTE et M. VALES 16. Dec. 1974; isotypi 27754 SV! et Bp!*

Fam.: **Polygonaceae**

Coccoloba praestans Borhidi sp. nova

(**Coccoloba coriacea** sensu Howard p.p. Journ. Arn. Arb. **30.** 1949. p. 406. non Sagra Fl. Cub. **11:** 184. 1853.)

Frutex vel arbuscula usque 4 m. alta. Rami teretes crassi ad nodos puberuli. Ochreae membranaceae 5—8 mm. longae, breviter pilosae. Folia 5—8 mm. longe petiolata, petiolis patenti-hirsutis suffulta, lanceolata vel oblonge-lanceolata, latitudine 2—4-plo longiora basi rotundata vel breviter cordata, nunquam amplexicaulia, antice sensim angustata non acumi-

* SV: Herbario de la Academia de Ciencias de Cuba; Santiago de las Vegas, Cuba. Bp: Herbario del Museo de las Ciencias Naturales Budapest, Hungria.

nata, acuta vel obtusa, 4—13 cm. longa et 2—5 cm. lata, nervo medio supra impresso vel ex sulco prominulo, subtus crasse prominenti et persistenter hirsuto, lateralibus utroque latere 9—14 supra applanatis vel leviter impressis, subtus bene prominentibus ante marginem bifurcatis et anastomosantibus, secundariis utrinque densissime reticulato-venosis, reticulo supra conspicuo, subtus prominulo et satis dense ruguloso hirsuto, lamina supra glabra, subtus ad nervos ruguloso-hirsuta, rariter glabrescens, punctis impressis utrinque carentibus vel rariter supra sparsissime praesentibus, margine revoluta, rigide coriacea. Inflorescentia terminalis 10—25 cm. longa, rhachis glabra vel papillosa, purpurea, crassa. Flores masculi plerumque solitarii, bracteae ovatae, 0,2—0,4 mm. longae, ochreolae membranaceae 0,5—0,7 mm. longae, pedicelli 5—12 mm. longi, purpurei, glabri. Perianthium 5—7 mm. longum purpureum, glabrum, hypanthium 1—2 mm. longum, lobi late ovati, 2,5—4,5 mm. longi et 2,5—3 mm. lati. Stamina 7—8; filamenta basi 0,5—1 mm. longe connata, superne 1,5—2,5 mm. longa, rosea vel purpurea, e lobis perianthii non exserta. Pedicelli fructiferi usque ad 1,5 cm. longi, baccae ovatae, 7 mm. longae, utrinque angustatae.

Holotypus: BORHIDI: 27805 SV!; Sierra de Nipe, in charrascosis montis Loma Bandera in alt. approx. 500 m.s.m. Leg. A. BORHIDI 13. Febr. 1976. Isotypus: Bp!

Specim. exam.: Sierra de Nipe: Punta Gorda to Woodfred, SHAFER 3543!; Alto de la Bandera LEÓN et ALAIN 19324!; LEÓN, MARIE-VICTORIN, CLEMENTE et ALAIN 19758! M. LÓPEZ FIGUEIRAS 2031!; 2060!; Arroyo Canapú, M. LÓPEZ-FIGUEIRAS 1875! — Sierra de Nipe, Mayari, CARABIA 3814!

Coccoloba coriacea A. Rich. s. str.

Frutex vel arbor parva, usque 7 m. alta. Folia 7—10 mm. longe petiolata, petiolis 3—4 mm. crassis, striatis glaberrimis suffulta, ovata vel late ovata, basi profunde auriculato-cordata, saepe amplexicaulia, antice plerumque breviter acuminata vel rotundata, apice ipso obtusa, 10—20 cm. longa, 6—11 cm. lata, latitudine 1,5—2-plo longiora, nervo medio supra applanato vel prominulo subtus bene prominenti, glabro, lateralibus utroque latere 6—9 supra applanatis, subtus prominentibus, marginem versus bifurcatis et anastomosantibus secundariis utrinque densissime reticulatis, supra conspicuis subtus levissime prominulis, utrinque glabris et punctis brunneis minutis impressis dense praedita, margine plana, coriacea. Inflorescentiae terminales, 10—20 cm. longae, rhachis glabra, purpurea, crassa. Flores masculi plerumque solitarii, bracteae lanceolatae, acutae, 0,5 mm. longae, ochreolae membranaceae, 0,5 mm. longae, caducae, pedicelli 5—8 mm. longi, purpurei, glabri. Perianthium 5—6 mm. longum, lobi obovati, 2,5—3,5 mm. longi et 1,5—2 mm. lati, hypanthium 2—2,5 mm. longum. Stamina 7—8, filamenta basi in tubum 3—4 mm. longum connata, superne 1,5—2,5 mm. longe libera, alba, e lobis perianthii breviter exserta.

Lectotypus: Prov. Pinar del Rio, Sierra de Cajalbana: Loma Preluda in charrascosis. Leg.: A. BORHIDI et R. CAPOTE 28. Jan. 1976. SV.! Isolectotypus: Bp!

Coccoloba oligantha Alain var. **elliptica** Borhidi var. n.

A typo differt: foliis ellipticis, 4—8 mm. latis, basi obtusis vel breviter cuneatis.

Holotypus: SV. 26071. Prov. Oriente, Región de Moa, Reservación de Cupeyal, al NE de Guantánamo. Leg.: S. GANTSHEFF, Marzo 1966.

Fam.: **Mimosaceae**

Pithecellobium asplenifolium Griseb. ssp. **mayarense** Borhidi ssp. n.

A typo differt: foliolis ellipticis vel obovatis, 1—1,8 cm. longis, 0,5—1,0 cm. latis, supra nitidis et bullescentibus, subtus concaviusculis et dense adpresse pilosis, margine revolutis, rhachidibus foliorum 4—8 cm. longis (in typo 2,5—5,5 cm.).

Holotypus: Cuba; Sierra del Cristal, Nicaro, Mayari, Montes United Fruit. Leg.: J. Acuña et Zayas 19663 SV.! 26—27. Mai. 1955.

Specim. exam.: Sierra del Cristal: Charrascos de la falda del Pico Cristal, 2—7. Apr. 1956, Acuña, Alain et López Figueiras (5800)! — Pinar de Micara, Leg.: Alain et López Figueiras (4637)!, 27. Dec. 1955. — Meseta entre Cabañas y Moa, Leg.: M.-Victorin, Clemente et Alain (21691 León!) Apr. 1943. — Sierra de Nipe: Loma de San José, cerca de Woodfred Pinal de Mayari. Leg.: León et Alain (17977)! 26. jul. 1940; — León, M.-Victorin, Clemente et Alain (19845)! 6. apr. 1941. — Cayo La Plancha, bosque humedo, alt. 750 m.s.m.; leg.: Alain et Acuña (8012!) 21. apr. 1960.

ssp. *asplenifolium*

Typus: Wright 2403! Cuba occ. (?) — Cumbre de Cayo Guam Punta Gorda, Moa; leg.: Acuña (12440!) Oriente 17. apr. 1945.

Fam.: **Caesalpiniaceae**

Cassia acunae Borhidi sp. n.

Rami hornotini flavo-strigilloso-hirtuli, stipulae lineari-subulatae, 4—7 mm. longae, flavo-villosae. Folia 4—5 cm. longe petiolata, 14—20-juga; rhachis eglandulosa, cum petiolo 15—25 cm. longa; foliola opposita, petiolulis 2—3 mm. longis, oblongo-lanceolata vel oblongo-ovata, basi obtusa, antice longe acuminata, apice ipso obtusiusculo et 1—2 mm. longe mucronulato, 4—7 cm. longa et 0,8—1,5 cm. lata, nervo medio supra impresso, lateralibus supra impressis, subtus bene prominentibus, utrinque dense reticulatis, reticulo subtus prominenti, supra glabra, nitida, subtus adpresse strigillosa, chartacea. Inflorescentiae corymboso-paniculatae, corymbi partiales pedunculis 1,5—2,5 cm. longis ad apicem confertim et subumbellatim multiflori; bracteae persistentes. Pedicelli 1—3 cm. longi, flavo-pubescentes. Sepala 2 exteriora naviculari-ovata, 4—5 mm. longa, interiora inaequalia suborbicularia usque ovata 6—8 mm. longa, valde concava, omnia margine pilosa et sub anthesi reflexa, in sicco nigrescentia. Petala 3—4 mm. longe stipitata, limbo suborbiculare 9—11 mm. longo et 8—10 mm. lato, antice rotundato, membranacea. Stamina 10; antherae 3 minimae, lineares, steriles 1,5—2 mm. longae, 4—5 intermediae 4 mm. longae basi sagittatae, 2—3 arcuato-curvatae 6—7 mm. longae. Ovarium arcuatum, glabrum. Legumen compressum, chartaceum, glabrum, 7—10 cm. longum et usque ad 1 cm. latum, intus septatum, extus irregulariter contractum. Semina ovata, nitida, nigra, 4 mm. longa et 3 mm. lata, compressa.

Holotypus: Cuba; Prov. Pinar del Rio. La Cajalbana, junto al arroyo La Palma. Leg.: J. Acuña, 27. jun. 1961. (flor.) 22698 SV!; isotypi: SV! Bp! — Ibidem, leg. J. Acuña 19. oct. 1950 (fruct.) 16418 SV!

Obs.: *C. gundlachii* Urb. (e Sierra de Nipe et Cristal, prov. Oriente) affinis, quae stipulis lineari-subulatis, 4—7 mm longis, foliis 2—3 cm longe petiolatis, 5—10-jugis, rhachide 6—15 cm. longa, foliolis minoribus, ovatis, sepalis glabris, floribus majoribus bene differt.

Cassia holguinensis Borhidi sp. n.

(**Cassia buchii** auct. cuban. non Urban)

Suffrutex ramosus, 10—20 cm. altus, basi lignescens. Rami pilis flavescentibus, rigidis, adpresse strigillosi; stipulis triangulari-lanceolatis, 3—5 mm. longis, setaceo-acuminatis, longitudinaliter nervatis. Folia petiolis 2—4 mm. longis, medio glandula scutellata, cca. 0,5—0,8 mm. longe stipitata, nigrescenti suffulta, 1,5—3 cm. longa, foliola 7—14-juga, sessilia, basi unilateraliter rotundata, apice supra nervum principalem breviter mucronata, linearia, leviter falcata, 5—10 mm. longa, 1—1,5 mm. lata, nervo principali unilaterali iuxta marginem obvio, lateralibus 6—8 utrinque praesertim subtus crassiuscule prominentibus, lamina supra nervos et ad marginem ± sparse strigillosa, inter nervos minutissime flavido-punctata; pedunculus 1,5—3 cm. longus, pilosulus, 4—5 mm. sub apice bracteas triangulari-subulatas 1,5—2 mm. longas gerens 1-florus. Sepala exteriora oblongo-lanceolata, aristato-acuminata, 6—7 mm. longa, interiora ovato-oblonga, apice subulato-acuminata, 8—10 mm. longa, omnia nervo medio dorso prominulo et sparse strigilloso suffulta et late membranaceo-marginata. Petala flava ± subaequalia, obovata, 9—11 mm. longa et 5—7 mm. lata, multi-nervia, nervis reticulato-anastomosantibus. Stamina 10, omnia perfecta, 3—4 majora 6—7 mm. longa, 6—7 minora 3—4 mm. longa, breviter rostrata, omnia 1 mm. longe stipitata. Ovarium lineare, dense adpresse strigillosum, stylus arcuatus, ovario paullo longior. Legumina sessilia, 2—3 cm. longa, linearia, 3—4 mm. lata, apice breviter acuminata, brunnescentia et parce strigillosa, intus dissepimenta praebentia, non reticulo-venosa. Semina 6—9, rhombea vel rectangularia, glandulis impresso-punctata.

Holotypus: Cuba; prov. Oriente: Lomas de Holguin. Leg.: M. López Figueiras 942! 3. apr. 753. SV!

Specimina examinata: Prov. Oriente: Loma Pilón, Holguin; leg. M. López Figueiras 1012! 8. nov. 1953. — Prov. Oriente: Yuraguanal, Hacienda Pesquero, Cacocum; leg.: H. León et J. Garcia Castañeda 15690!, 4. jul. 1932. — Cerro del Fraile, Holguin; leg.: H. León, 16296!, 27. jul. 1935.

Obs.: *C. strigillosae* Benth. affinis, quae petiolis glandula sessili suffultis, foliolis 4—6 mm. longis, postremo glabris, epunctatis, floribus minoribus differt; *C. buchii* Urb. a specie nostra ramis brevissime pilosis, foliis 2—3.5 cm. longis, foliolis glabris et epunctatis, sepalis glabris, interioribus apice obtusis, petalis majoribus, inaequimagnis, seminibus eglandulosis certe diversa.

Caesalpinia bahamensis Lam.

1 a Pinas y foliolos sin estipulas espiniformes, pinas 2—3 pares, foliolos 3—6 pares, obovados ..... ssp. **bahamensis**

b Pinas con estipulas espiniformes, pinas 3—6 pares, foliolos 6—9 pares, oblongo-elipticos o estrechamente obovados 2

2 a Foliolos brevemente peciolulados, sin estipulas espiniformes rectas, el raquis peloso a glabro ..... ssp. **rugeliana**

b Foliolos subsesiles, con estipulas espinosas rectas; el raquis puberulo a tomentoso ..... ssp. **orientensis**

Las plantas rugelianas, colectadas en la zona costera de la ciudad Matanzas, son indudablemente identicas con las de las costas rocosas de la provincia Habana, (recolectadas varias veces por H. León). El isotipo de la *Caesalpinia rugeliana* Urb. en Herbario Sauvalle (Wright 2364, revisado por Urban) es conspicuamente una mezcla de ejemplares de distintas poblaciones. Una parte de las ramas son identicas con las plantas de la zona costera de las provincias Habana—Matanzas, y solamente la mitad del material tiene origen de poblaciones de Oriente — con gran probabilidad. De esta manera la descripción de Urban esta basada en poblaciones lejanas, que se distinguen en algunas caracteristicas, y pues reune caracteristicas, que no se encuentran juntas en las poblaciones cubanas. Nuestra opinión es, que la *C. bahamensis* Lam. sensu Britton es una especie bastante variable, que se segrega en varias razas geográficas más o menos bien definidas. Estas son las siguientes:

ssp. **rugeliana** (Urb.) Borhidi comb. et status n.

(Basionym: **Caesalpinia rugeliana** Urban Symb. Ant. *2.* 1901. p. 199.)

Folia sub pinnarum insertione plerumque aculeis geminis vel solitariis obsita, 3—6-juga, foliolis 6—9-jugis, inermibus, anguste obovatis vel oblongis, 1—2 mm. longe petiolulatis, rhachide subglabra vel sparse pilosula.

Wright 2364 in Herb. Sauv. p.p.! Lectotypus: Cuba, Prov. Habana; Playa de Marianao; leg. H. León 5628! 16. sept. 1915. SV.

ssp. **orientensis** Borhidi ssp. n.

Folia sub pinnarum insertione aculeata, foliolis 6—9-jugis stipellis spiniformibus rectis, 1—3 mm. longis suffultis, subsessilibus basi et nervo medio subtus puberulis, rhachide pubescenti vel tomentosula.

Wright 2364 in Herb. Sauv. p. p.! Holotypus: Cuba; Prov. Oriente; manigua costera en las cercanias del aeropuerto de Santiago de Cuba; leg.: M. López Figueiras 1142! 14. mart. 1954. SV!

Specimina examinata:

ssp. *bahamensis:* Bahamas: New Providence near Nassau, 7. apr. 1904! leg.: N. L. Britton; — Ibidem, Curtiss 128! mart.—mai. 1903. — Cuba: Prov. Habana; Santiago de las Vegas, cultivada, 10990! SV. — Isla de Pinos: Sierra de las Casas, 28. apr. 1954. leg.: Killip 44166! SV. — Rio Casas, Nueva Gerona, 3 febr. 1953. leg.: Killip 42581! SV.
ssp. *rugeliana* (Urb.) Borhidi: Prov. Pinar del Rio: Toscano, Bahia Honda; leg.: J. Acuña et J. T. Roig 21. oct. 1951. 23607 SV! — Pinar del Rio, leg.:

J. T. Roig Herb. Min. Agr. 949!, 952!, leg.: A. Fors Herb. Min. Agr. 25! — Remates de Guane; leg.: J. Acuña et Correl 12. apr. 1938. Herb. Min. Agr. 557! — Las Martinas, leg.: J. Acuña et J. T. Roig 16996! SV. — Peninsula de Guanahacabibes: Maria La Gorda, leg.: J. Acuña et F. Zayas 24. jul. 1955. 19864 SV! — Isla de Pinos, leg.: Clara de Pinal, mai. 1967. 26418 SV! — Cerro Daguilla, leg.: Killip, 12. apr. 1954. 43987 SV. — Prov. Habana: Cojimar, leg.: Baker, 1. jul. 1905. 5319 SV!, 5344 SV!. — Playa de Bacuranao, leg.: H. León 5. aug. 1909. 1380!, 11. jul. 1911. 2624!. — El Salado, Banes, leg.: H. Alain 3042! 27. jun. 1953. — Prov. Las Villas: Antón Recio, leg.: H. León et H. Nestor 11. apr. 1930. 14316! — Santa Clara, Rio Primero 27. mart. 1934. leg.: H. León 16073! — Sabanas Caimiabo entre Sancti Spiritus et Jibaro 29. aug. 1950. leg.: H. Alain 1603! — Prov. Camagüey: Nuevitas, leg. J. T. Roig 23. febr. 1916. 6486 SV! — Sabana de Guanamaquilla; leg.: Roig, Luaces et Aranjo, 3. mai. 1915. 6012 SV!.

ssp. *orientensis* Borhidi: Prov. Oriente: Central Manati, Sabanalamar; leg.: H. León et S. Clark 15732! 6. jul. 1932. — Puerto Padre; leg.: M. Curbelo 16995 SV! — Playa Herradura, Puerto Padre; leg.: Diaz-Piferrer 23. aug. 1960. 21409 SV! — Monte cerca de Cacocum, leg.: H. León 15692! 4. jul. 1932. — Bahia de Nispero, leg.: H. Clemente 6028! apr. 1948. — Bahia de Santiago de Cuba: Cinco Reales; leg.: H. León et H. Pedro 3750! 2. aug. 1913. — Santiago de Cuba, leg.: H. Chrysógone 7517! febr. 1951. — Camino del Morro, Santiago de Cuba, leg.: H. Clemente 2909! jul. 1943. — Ibidem, H. León et Dahlgren 22895! 19. mai. 1947. — Renté, Santiago de Cuba, leg.: H. Hioram 2043! 30. jul. 1918. — Ibidem, H. Clemente 2760!, H. Clemente sine numero nov. 1932. H. León 9800! — Imias, leg.: H. León 12261! 17. jul.—4. aug. 1924.

Fam.: **Fabaceae**

Brya hirsuta Borhidi sp. n.

(**Brya buxifolia** auct. Florae Cub. non Urban)

Frutex usque ad 2—3 m. altus; ramuli dense et adpresse hirsuti, aculeis recurvis, 1—2 mm. longis; folia alterna vel fasciculata, 0,5 mm. longe petiolata, elliptica, suborbicularia vel late obovata, basi apiceque rotundata, 2—5 mm. longa et 1,5—3 mm. lata, supra pilis erectis glandulosis patenti-hirtula, subtus pilis sericeis longioribus adpresse strigoso-pubescentia. Flores laterales solitarii vel 2—4 fasciculati, pedicelli 2—6 mm. longi, patente hirsuti vel villosuli. Bracteae et prophylla linearia, hirsuta, 2 mm. longa. Calyx 4,5—5 mm. longus, sericeo-villosus, lobi 2—2,5 mm. longi, tubo ± aequilongi, inter sese leviter inaequimagni, ovati vel inferiores lanceolati, omnes acuti et acuminati, utrinque hirsuti vel villosuli. Petala aurantiaca vel ochracea. Vexillum 8—10 mm. longum et 5—6 mm. latum, limbus ipse suborbicularis, 7—8 mm. longus et 5—6 mm. latus, carina alis ± aequilonga, limbo 8—9 mm longo, unguiculum 4—5-plo superante. Androeceum 9—10 mm. longum, gynoeceum cum stylo 11—12 mm. longum. Legumen suborbiculare, parte inferiore truncatum, 1—2-articulatum, breviter stipitatum, 8—17 mm. longum, dense albo-hirsutum.

Holotypus: Cuba; prov. Oriente. In fruticetis spinosis serpentinosis ad Ceja de Melones inter pag. Santa Lucia et Holguin. Leg.: A. Borhidi 14. febr. 1976. 27800 SV!; isotypi: 27799 SV! et Bp!

Specimina examinata: Prov. Oriente: Cerro Galano, La Palma, Holguin; leg.: A. Borhidi, R. Capote et Ramóna Oviedo, 25. sept. 1975! — Sierra de Nipe: Rio Piloto in alt. approx. 800 m.s.m.; leg.: A. Borhidi, R. Capote et Ramóna Oviedo 6. sept. 1974! — Sierra de Nipe: Charrascal de la Cueva; leg.: H. León et H. Marie-Victorin 1942!

Obs.: Foliorum forma, magnitudine et indumento *B. buxifoliae* Urb. (ex insula Hispaniolae) affinis, a qua floribus majoribus, vexillo 8–10 mm. longo, carina alis subaeqilonga, atque androeceo gynoeceoque 2—3-plo longiore omnino differt.

Fam.: **Erythroxylaceae**

Erythroxylon horridum Borhidi et Oviedo sp. n.

Frutex ramosissimus usque ad 1 m. altus. Rami teretes, circumcirca elati, rigidissimi, depressi, cortice griseo praediti, apice attenuati, in fasciculos stipularum excurrentes, posterius spiniformi-pungentes. Ramuli primi ordinis subrectangulariter patentes, numerosissimi, valde approximati, 2—5 cm. longi, apice attenuati, spinescentes, ramuli secundarii et tertii ordinis brevissimi, teretes, rigidi, apice conferte foliosi. Folia minima, petiolis 0,5—1 mm. longis, albido-pulverulentibus suffulta, suborbicularia, ovata vel late elliptica, apice rotundata et breviter emarginata, basi rotundata vel obtusa, 4—7 mm. longa et 3—5 mm. lata, utrinque reticulato-venosa, glabra, supra viridia, in sicco nigrescentia, subtus glaucescentia, utrinque opaca, chartacea. Stipulae persistentes, triangulares, 1 mm. longae, acutae et longe apiculatae, margine membranaceae et fimbriatae, ferrugineo-brunneae. Flores in apice ramorum secundi et tertii ordinis terminales vel subterminales, solitarii, 5-meri. Pedicelli 1—2 mm. longi, 5-angulati, apicem versus valde incrassati. Calyx usque ad 4/5 partitus, lobi triangulares 0,5—0,6 mm. longi, albo-marginati, apice obtusi, leviter inaequilongi. Petala 1—1,5 mm. longa, lamina ovata, late membranaceo-marginata, pallide lutea, 1/4 longit. lamin. late unguiculata, ligula majuscula instructa, auriculae laterales integrae lobulo commissurali brevi aequilongae. Stamina 10, exserta, usque ad 2 mm. longa; urceolus stamineus calyce dimidio brevior. Ovarium urceolo ± aequilongum, ovatum, triquetrum, stigmata minuta subsessilia, styli brevissimi crassi. Drupa 4—5 mm. longa, 2,5 mm. in diam., oblongo-ellipsoidea, manifeste 3-gona, apice breviter apiculata, obtusiuscula.

Holotypus: Cuba; prov. Oriente. In fruticetis serpentinosis aridis ad Ceja de Melones, prope opp. Holguin; leg.: A. Borhidi, R. Capote et Ramona Oviedo 24. sept. 1975. 27791 SV!, isotypus: Bp!

Obs.: *E. spinescenti* A. Rich. habitu affinis, quod ramis hornotinis lucide brunneis, foliis obovatis, majoribus, basi cuneatis, floribus axillaribus 1—3, majoribus, stylis tenuibus, fructibus majoribus, 6-angulatis omnino differt. *E. echinodendron* Ekman (ex descr.) foliis lucidis, crasse coriaceis, subtus ferrugineis, stipulis minoribus atque floribus fructibusque certe diversum.

Erythroxylon clarense Borhidi sp. n.

Frutex ramosus, 1—2 m. altus. Rami hornotini brunnei, glabri, angulati, vetustiores teretes, grisei, striati. Stipulae dense obsitae, triangulares, apice tridentatae. Folia 1—2 mm. longe petiolata, elliptica vel leviter obovata, 1—2,5 cm. longa et 0,5—1,3 cm. lata, apice rotundata et emarginata, basi obtusa, utrinque reticulato-venosa, venis supra prominulis, subtus conspicuis, lamina supra nitidula, subtus opaca et inter nervos albo-punctata, subchartacea. Flores in axillis stipularum solitarii, subsessiles, Calycis lobi 0,7—1 mm. longi, acuminati et acuti, usque ad 1/2—1/3 longitudinis incisi. Petala obovata, 1/3 longe unguiculata, 1,5—2 mm. longa, ligulae in alt. 1/3 insertae, anticae posticis 2-plo longiores, posticae lobulo inflexo tenuissimo conjunctae; urceolus stamineus calyce brevior. Stamina 0,5 mm. longa, ovarium urceolo manifeste brevius, ovatum; stylus 1 mm. longus.

Holotypus: Cuba; prov. Las Villas. Sierra de Escambray, en la cresta rocosa del Pico Potrerillo, alt. 930 m.s.m.; leg.: H. Alain 6691! 2. apr. 1959.

Specim. exam.: Sierra de Escambray: subida a Buenos Aires, San Blas. Leg.: J. Acuña et J. Roig 24269 SV!

Obs.: *E. alaternifolio* A. Rich. affinis, quod foliis coriaceis, utrinque nitidis statim discernendum est.

Erythroxylon baracoënse Borhidi sp. n.

Frutex 2—3 m. altus. Rami hornotini brunnei, glabri, vetustiores cinereo-ferruginei, lenticellis longitudinaliter oblongis, suberosis, valde prominentibus verrucosi. Folia 1—5 mm. longe petiolata, obovata vel elliptica, antice rotundata et valde emarginata, basi obtusa vel rotundata, 2—5 cm. longa et 1,5—3,5 cm. lata, nervo medio supra profunde impresso, subtus carinato-prominenti, lateralibus utrinque prominentibus et densissime reticulatis, lamina utrinque nitida, glabra, supra in sicco olivaceo-brunnea, subtus ferruginea et minutissime ferrugineo-punctata, in areolis nervorum tuberculis puncti- et bacilliformibus prominulis suffulta, rigide coriacea. Stipulae persistentes 1—1,5 mm. longae, triangulares, apice acuminatae et longe bidentatae, dentibus caducis. Flores 3—4 mm. longe pedicellati, solitarii. Calyx 0,7—1 mm. longus, lobi usque ad dimidium incisi, triangulares et acuti. Petala oblongo-elliptica, apice acutiuscula, 1,5 mm. longa, usque ad 2/3—3/5 longitudinis laminae unguiculata, ligula in 3/5 longit. lam. instructa; auriculae laterales anticae posticis 3-plo longiores, posticae lobulo inflexo minuto conjunctae. Flores dolichostyli: urceolus stamineus calyce paullo brevior, filamenta brevissima, 0,2 mm. longa, antherae rudimentariae 0,1—0,2 mm. longae. Ovarium 1—1,2 mm. longum, obovatum, urceolum 1,5-plo superans. Stylus subnullus; stigmata horizontaliter lobulata. Drupa 4-angulata, 6—7 mm. longa, 2—3 mm. in diam. oblonga, breviter apiculata.

Holotypus: Cuba; prov. Oriente: in summo montis calcarei Yunque de Baracoa. Leg.: M. López Figueiras 27. jul. 1960. UO 2292 SV!

Specim. exam.: Yunque de Baracoa, leg.: H. Alain et J. Acuña 7527! 758! 14. jan. 1960. — Ibidem. leg.: H. Alain et M. López Figueiras 7175,! 7221! 2. jan. 1960.

Erythroxylon flavicans Borhidi sp. n.

Frutex 2—3 m. altus, valde ramificatus. Rami hornotini flavicantes vel brunnei, glabri, vetustiores cinerei, striati. Folia 1—2 mm. longe petiolata, obovata, antice rotundata vel truncata, apice emarginata, basi cuneata vel obtusiuscula, 0,7—1,5 cm. longa et 4—9

mm. lata, nervo medio supra impresso, subtus prominenti, lateralibus supra obsoletis, plerumque non reticulatis, subtus levissime prominulis et obsolete reticulatis, lamina supra in sicco olivaceo-viridis vel canosa, subtus pallide flava in areolis venarum minute flavopunctata, utrinque opaca, glabra, rigide coriacea. Stipulae persistentes, usque ad 1 mm. longae, late triangulares, apice mucronatae. Flores 1—2, axillares, pedicelli 1—2 mm. longi, lobi calycis 0,7 mm. longi, triangulares, acuti, 1/2—2/3 longit. incisi. Petala oblongo-elliptica, 2—2,3 mm. longa, 1/3—2/5 longit. unguiculata, ligulae in 1/3—2/5 altit. insertae, anticae posticis 2-plo longiore, posticae perfecte separatae. Urceolus stamineus calyce aequilongus, filamenta 0,2 mm. longa, staminodia 0,2 mm. in diam., orbiculares. Ovarium obovatum 1,7—2 mm. longum. Styli 3, 0,2—0,3 mm. longi, horizontaliter elati stigma obovatum vel orbiculare. Fructus non pleno maturus 4—5 mm. longus et 2 mm. latus.

Holotypus: Cuba; prov. Oriente: Sierra del Cristal; in fruticetis semper-virentibus serpentinosis montanis Mt. Saca Lengua in alt. approx. 650 m.s.m., leg.: A. Borhidi, M. Vales et Ramona Oviedo 11. apr. 1976. 27819 SV!; isotypus: Bp!

Obs.: Species proxima *E. dumosum* Alain (e Sierra de Nipe) a specie nostra foliis duplo majoribus, nervis lateralibus utrinque prominentibus et reticulatis, floribus sessilibus, petalis obovatis, filamentis multo longioribus clare differt.

Fam.: **Rutaceae**

Ravenia baracoënsis Borhidi et Muñiz sp. n.

Frutex vel arbor parva, usque ad 5—6 m. alta. Rami hornotini angulosi, sulcati, breviter et adpresse ferrugineo-puberuli, vetustiores teretes, striati, lenticellis prominentibus obsiti. Folia 5—15 mm. longe petiolata, petiolis supra profunde sulcatis, ± puberulis suffulta, simplicia, obovata vel late elliptica, basi cuneata et in petiolum protracta, apice acuta et mucronata, breviter acuminata, rariter obtusa, 4—11 cm. longa et 2—4,5 cm. lata, nervo medio supra impresso, subtus crassiuscule prominente, lateralibus utroque latere 6—9 supra non vel vix conspicuis, subtus tenuiter prominulis vel obsoletis, ante marginem conjunctis, lamina supra glandulis impressis dense minuteque nigro-punctata, subtus glandulis vix prominulis mox evanescentibus obsita, supra glaucescens, subtus brunnescens, utrinque opaca, margine tenuiter revoluta, coriacea. Inflorescentiae terminales 1—3-florae, pedunculus usque ad 5 cm. longus, adpresse strigillosus. Prophylla 1—2 mm. longa, puberula, pedicelli 5—20 mm. longi. Sepala 2 exteriora oblongo-triangularia vel oblongo-ovata, apice obtusa, 10—14 mm. longa et basi 3—5 mm. lata, dense glandulosa, in fructu non accrescentia; interiora 2 orbicularia, 3—4 mm. longa, glanduloso-punctata, ad marginem membranacea et pilosa. Corolla 2,5—3 cm. longa, purpurea, glanduloso-punctata; tubus 15 mm. longus, superne sensim ampliatus; lobi 5, obovati, antice rotundati, tubo quasi aequilongi. Antherae 2, subsessiles, filamentis brevissimis, longitudinaliter connatis, apice bilobatis suffultae, oblongo-ellipticae, 3—4 mm. longae, connatae. Staminodia 3, arcuata, linearia, 2—3 mm. longa. Stylus tubo ± aequilongus, cylindricus, apice inaequaliter 5-lobatus. Carpella 5, elevatim nervosa, 7—9 mm. longa, nigro-punctata. Semina singula in quoque carpello, subreniformia, nigra, opaca, 4 mm. longa, spinuloso-tuberculata.

Holotypus: Cuba; prov. Oriente. "En charrascales de la 'Ermita' al Este de Yunque de Baracoa." Leg.: H. Alain, J. Acuña et J. Ramos 7573, 15. jan. 1960. SV!, isotypi: SV!

Specim. exam.: Charrascal junto a la carretera de Quibiján, Via Mulata, Baracoa. Leg.: H. Alain et M. López Figueiras 7266, 3. jan. 1960.!; — La Ermita, Baracoa; leg.: E. Del-Risco 2. febr. 1973. 27412 SV!

Obs.: *R. simplicifoliae* Wr. in Wils. affinis, quae foliis oblongo-ellipticis, utrinque lucidis, sepalis majoribus, ovatis vel late ovatis, 7—10 mm. longis, antheris non connatis certe specifice differt.

Fam.: **Euphorbiaceae**

Acidocroton acunae Borhidi et Muñiz sp. n.

Frutex spinosus. Rami hornotini brevissime adpresseque pilosi, vetustiores dense tuberculati. Spinae stipulares divaricatae, rectae, 7—15 mm. longae. Folia 0,5—1 mm. longe petiolata, obovata vel obovato-spathulata, inferne longe angustata, antice rotundata, 2—5 mm. longa et 1—3 mm. lata, nervo medio supra impresso vel inconspicuo, subtus tenuiter prominulo, pilis parcis obtecto, postremo glabro, lateralibus utrinque nullis, lamina supra nitidula et leviter plicatula, rigide coriacea. Flores masculi e pulvinulis lateralibus terminalibusque 1—4-natim prodeuntes; pedicelli 3—5 mm. longi. Sepala 5—6, sublibera, in aestivatione aperta, elliptica, margine dense ciliata, cca. 1 mm. longa. Petala 5, valde cochleatim imbricata, orbiculari-ovata, apice rotundata, 2,5 mm. longa et lata, margine recurva, minute pilosa, chartacea. Receptaculum leviter convexum, breviter et densissime rufo-pilosum. Stamina 16, per totam superficiem receptaculi pluriseriatim inserta, filamenta 0,3—0,6 mm. longa, antherae erectae, 1 mm. longae, lanceolatae, apice acutae; ovarii rudimentum nullum. Flores feminei ex pulvinis supremis 1—3; pedicelli 4—6 mm. longi, superne incrassati. Sepala libera, in aestivatione aperta, basi inter sese tangentia, linearia vel oblongo-oblanceolata, integra vel acute dentata vel lobulata, 4—6 mm. longa, fructibus ± aequilonga, 0,7—1 mm. lata. Discus annularis dense pilosus. Ovarium ovale, parce adpresse pilosum. Styli 3, basi connati, ceterum liberi, carnosi, lineares, 1,5—2 mm. longi, apice bifidi, lobis bifurcatis, lobulis ellipticis, obtusis. Capsula globosa, plerumque glabra, 4—6 mm. longa.

Holotypus: Cuba; prov. Las Villas: Sabana al Sur de Santa Clara. Leg.: J. Acuña et Alonso 26. aug. 1953. 18869 SV!

Specim. exam.: Prov. Las Villas: Sabana de Motembo; leg.: H. León et H. Roca 8210! 10. aug. 1918. — Ibidem, H. León et A. Loustalot 9321! 10. aug. 1920.

Obs.: *A. oligostemoni* Urb. (ex Oriente meridionali) affinis, qui foliis majoribus, petalis masculinis margine glabris, staminibus uniseriate dispositis, sepalis femineis obovatis vel spathulatis, 2—4 mm. longis, capsula dimidio brevioribus, capsulis majoribus differt.

Bonania suborbiculata Borhidi et Urbino sp. n.

Frutex 1—2 m. altus, inermis, glaber. Rami hornotini in sicco angulati, brunnei, nitidi, transversim striati. Stipulae ovato-orbiculares vel late triangulares, adpressae, rigidae, coriaceae, postremo nigrae, 1—1,5 mm. longae. Folia 1 mm. longe petiolata, petiolis supra planis, 1 mm. latis suffulta, orbicularia vel orbiculari-obovata, basi rotundata, subcordata vel truncata, apice rotundata vel truncata, semper profunde emarginata et mucronulata, 1—2 cm. longa et 0,8—1,8 cm. lata, nervo medio supra inferne leviter impresso, superne applanato et evanescenti, lateralibus utroque latere 4—6, supra nullis, subtus obsoletis, margine utroque latere glandulis minutis 5—8-denticulata, tenuiter recurva, lamina supra nitidula, viridis, subtus pallida, flavicans, chartacea. Inflorescentiae masculinae axillares vel basi ramorum hornotinorum laterales, 3—4 mm. longae et 2,5—3 mm. in diam.; bracteae

triangulares, usque ad 1 mm. longae, 1—2-florae. Calyx purpureus, 1 mm. longus, breviter 2—3-lobatus; stamina 3, sessilia, antherae breviter exsertae. Flos femineus ad basim inflorescentiae masculinae vel in axillis foliorum solitarius. Calyx 3-lobatus, lobi calycis orbicular-obovati, apice rotundati et abrupte subulato-mucronati. Capsula depresse globosa, 5—6 mm, alta et 8—9 mm. in diam., glabra, brunnea, 3-costata. Semina 3 mm. in diam., globosa. cinereo-brunnea, marmorata.

Holotypus: Prov. Oriente: in fruticetis sempervirentibus serpentinosis montis Cerro Galano prope opp. Holguin, alt. 250 m.s.m.; leg.: A. Borhidi, R. Capote et Ramona Oviedo 25. sept. 1975. 27806 SV!. Isotypi: 27807 SV! et in Bp!

Obs.: *B. nipensi* Urb. et Ekm. affinis, quae foliis obovatis vel obovato-ellipticis, 2—3.5 cm. longis et 1—2.5 cm. latis, nervis lateralibus 8—11, subtus prominentibus et anastomosantibus, fructibus majoribus differt.

Bonania acunae Borhidi sp. n.

Frutex ramosus; rami hornotini angulato-striati, brunnei, glabri. Folia 1,5—4 mm. longe petiolata, petiolis nigris, glabris, 0,5 mm. crassis, supra sulcatis suffulta, late ovato-suborbicularia, antice rotundata et emarginata, basi truncata, 1,2—2,6 cm. longa et 0,9—2,3 cm. lata, nervo medio utrinque prominenti, lateralibus numerosissimis utrinque tenuiter prominentibus et densissime reticulato-anastomosantibus, margine serrato-denticulata, utrinque glabra, subcharatacea. Flores nobis ignoti. Fructus sessilis vel subsessilis, ovatus, apice acutiusculus, 6—7 mm. longus, glaber. Semina cinerea, globosa, 4—4,5 mm. in diam.

Holotypus: Cuba; Prov. Oriente; Meseta de Maisi. Leg.: J. Acuña et D. Barreto 6. febr. 1952. 17387 SV!

Specim. exam.: Mesa del Chivo, Maisi; leg.: H. León, Marie-Victorin et Carabia 17158/c — Maisi: manigua costera; leg.: H. León 16571/b, jul. 1935.

Obs.: *B. cubanae* A. Rich. affinis, quae foliis 1.5—2 mm. longe petiolatis, oblongo-ovatis vel ellipticis, basi rotundatis vel subcordatis, crassiuscule et remote reticulato-venosis, subcoriaceis, fructibus depresse—globosis, usque ad 5 mm. longis bene differt.

Moacroton lanceolatus Alain var. **varius** Borhidi var. n.

A typo differt: foliis lineari-lanceolatis, 3—7 cm. longis et 4—12 mm. latis, apice 1—2 mm. longe mucronatis, floribus femineis cum 4—6, plerumque 5 sepalis.

Holotypus: Cuba; prov. Oriente: in fruticetis serpentinosis aridis montis Cerro Galano ad pag. La Palma, Holguin; leg.: A. Borhidi, R. Capote et Ramona Oviedo 25. sept. 1975. 27793 SV!; isotypi: SV!, Bp!

Fam.: **Buxaceae**

Buxus acunae Borhidi et Muñiz sp. n.

Frutex; rami hornotini quadranguli, glabri. Folia apice ramorum conferta, 1,5—2 mm. longe petiolata, petiolis decurrentibus suffulta, ovata vel elliptica, basi obtusa vel rotundata et in petiolum brevissime protracta, antice obtusa vel rotundata, apice ipso breviter mucronato-pungentia, 1—2,5 cm. longa et 0,7—1,7 cm. lata, nervo medio supra impresso, lateralibus utroque latere 6—10, utrinque obsoletis vel plerumque supra nullis et subtus levissime prominulis, non reticulatis, ante marginem conjunctis, lamina supra nitens, olivaceo-brunnea, subtus opaca, margine plerumque valde revoluta, rigide coriacea. Inflorescentiae axillares, 1—2 cm. longae. Bracteae 0,5 mm. longae, ad basim pedunculi paucae. Pedunculus 6—12 mm. longus, ebracteatus, glaber; flores apice pedunculi conferti, masculini 4, spiraliter dispositi, 0,2—4 mm. longe pedicellati, bracteolis 1 mm. longis, triangulari-ovatis suffulti. Sepala 4, oblongo-ovata vel oblongo-lanceolata, 2—2,5 mm. longa, apice acuta, margine brevissime pulverulento-pilosa, lamina convexa, crasse coriacea. Stamina 4, sepalis opposita, in sinus disci 4-lobulati inserta, subsessilia; filamenta crassa, 0,3—0,5 mm. longa et lata; antherae ovatae, 1—1,5 mm. longae, sepalis breviores. Flos femineus terminalis solitarius, sessilis, bracteis breviter triangularibus circumdatus, sepala 4, late triangulari-ovata, 0,7—1 mm. longa, apice acuta. Ovarium 1,5 mm. longum, styli semiorbiculariter recurvati, 1,5—2 mm. longi. Fructus 6—7 mm. longus. Semina 4—5 mm. longa, lucida, nigra.

Holotypus: Cuba; Prov. Oriente: Breňales de Playa de Vaca, Moa. Leg.: J. Acuña 9. nov. 1945. 13168. SV!

— Ibidem, J. Acuña 11. apr. 1945 12515. SV!

Obs.: *B. bahamensi* Baker affinis, quae a specie nostra foliis basi angustatis, inflorescentiis brevioribus, staminibus longis exsertisque, filamentis tenuibus, sepalis femineis oblongo-ovatis, fructibus minoribus diversa. Altera species *B. rheedioides* Urb. (e Sierra de Nipe) foliis apice acutis et acuminatis, nervis lateralibus utroque latere 5—7 supra prominentibus differt.

Buxus historica Borhidi et Muñiz sp. n.

Frutex; rami hornotini subquadranguli, resinoso-papillosi, flavo-virides, glabri, internodiis 2,5—5 cm. longis. Stipulae oblongo-lanceolatae 0,6—1 cm. longae, coriaceae, glabrae. Folia 3—5 mm. longe petiolata, ovata vel ovato-elliptica, basi obtusa vel rotundata et in petiolum protracta, antice obtusa vel rotundata, apice ipso breviter retusa et emarginata, 3,5—6 cm. longa et 1,5—3 cm. lata, nervo medio supra tenuiter impresso, subtus prominenti, lateralibus utroque latere 12—18 supra prominentibus et anastomosantibus, ad marginem obsoletis et non vel vix conjunctis, subtus prominulis vel obsoletis, lamina supra nitens, flavo-viridis, subtus opaca et brunnea, margine tenuiter revoluta, coriacea. Inflorescentiae fructiferae tantum visae; breves, axillares, 1,5—2 cm. longae. Pedunculus 5—15 mm. longus, bracteis lanceolatis, acutis, 1—1,5 mm. longis, supra et ad marginem ferrugineo-tomentosis densissime obtectus. Flores masculi 4, pedicelli 2—3 mm. longi, compalanti, glabri, sepala 4, ovata, apice acuminata et acuta, 1,5—2 mm. longa, extus glabra, intus tomentosula; stamina 4, longe exserta, 4 mm. longa, filamenta filiformia, 3 mm. longa, glabra; antherae ovatae, 1 mm. longae. Flos femineus terminalis sessilis, solitarius. Sepala 5, suborbicularia, margine et intus tomentosula, dorso carinata, apice in mucronem aristatum excurrentia. Capsula subglobosa, brunnea, glabra, 7—9 mm. longa, styli breves, 2—3 mm. longi, recti, subhorizontaliter patentes. Semina 4—5 mm. longa, brunnea, nitida.

Holotypus: Cuba; Prov. Oriente. Charrascos, Sierra de Moa, en alt. aprox. 800 m.s.m. Leg.: H. Alain 3428! 26. jul. 1953. SV!

Obs.: *B. retusae* (Griseb.) Muell. Arg. (e Monte Verde) affinis, quae a specie nostra foliis basi angustatis, nervis lateralibus utrinque prominulis, inflorescentiis sessilibus, pedicellis masculinis 5—7 mm. longis et bracteis glabris satis differt.

Fam.: **Aquifoliaceae**

Ilex nannophylla Borhidi et Muñiz sp. n.

Frutex valde ramosus, usque ad 2 m. altus. Rami tortuosi, hornotini leviter angulati, brunnei, brevissime patenti-pilosi, vetustiores cinerei, glabri. Folia 1—2 mm. longe petiolata, petiolis minute pilosis suffulta, orbicularia vel late ovata, basi obtusa vel breviter rotundata, apice plerumque acuta et breviter acuminata, 5—12 mm. longa et 3—10 mm. lata, nervo medio supra profunde impresso, subtus crassiuscule prominenti, lateralibus supra nullis, subtus utroque latere 3—4, prominulis et reticulato-anastomosantibus, margine recurva, apicem versus 1—3-denticulata, supra nitida, subtus opaca, utrinque glabra.

Holotypus: Cuba; Prov. Oriente: Sierra Maestra, in fruticetis subalpinis montis Pico Cuba, 1800 m.s.m. Leg.: A. Borhidi 1731; 5. dec. 1969. 27047 SV!, isotypus: Bp!

Fam.: **Celastraceae**

Crossopetalum cristalense Borhidi sp. n.

Frutex 1—1,5 m. altus; rami hornotini tenuiter 4-alati, vetustiores 4-lineati, brunnei, griseo-maculati, transversaliter lenticellati vel fissurati, glabri. Folia subopposita, 1—2 mm. longe petiolata, elliptica vel levissime ovata, antice rotundata vel truncata, leviter emarginata, basi obtusa et in petiolum protracta, 1—3 cm. longa et 0.7—1,3 cm. lata; nervo medio supra impresso vel ex sulco inferne prominulo, subtus crasse carinato-prominenti, lateralibus utroque latere 4—6, supra nullis vel obsolete impressis, subtus bene prominentibus et obsolete reticulatis; lamina margine tenuiter revoluta, superne denticulata, in sicco supra flavido-brunnea, subtus viridis, subcoriacea. Inflorescentiae axillares, cymosae, 3—9-florae, glabrae. Pedunculus 5—10 mm. longus, bracteae 0,7—1 mm. longae, margine brevissime ciliatae; pedicelli glabri. Sepala in 2/3 longit. connata, lobi liberi 0,5 mm. longi, semiorbiculares, plerumque perfecte glabri vel margine brevissime ciliati. Petala ovata, 1—1,2 mm. longa, in fructu persistentia, reflexa. Fructus valde asymmetricus, purpureus, 8 mm. longus et 6 mm. latus.

Holotypus: Cuba. Prov. Oriente; Sierra del Cristal, in fruticetis semper-virentibus serpentinosis montis Cayo Verde, prope pag. Corea in alt. 780 m.s.m. Leg.: A. Borhidi, M. Vales et Ramona Oviedo 10. apr. 1976. 27774 SV! Isotypus: Bp!

Obs.: *C. rhacomae* (L.) Crantz affinis, quae a specie nostra foliis basi cuneatis, nervo medio tenui, supra prominenti, lateralibus plerumque nullis, pergamaceis, inflorescentiis atque sepalis puberulis clare differt. *C. shaferi* (Britt. et Wils.) Alain foliis obovatis, 2—3-plo majoribus, coriaceis, margine integris vel obsolete crenulatis, inflorescentiis laxis, late ramificatis, (6)—12-floris, pedunculis 10—15 mm. longis certe distat.

Fam.: **Sapindaceae**

Thouinia baracoënsis Borhidi sp. n.

Frutex 2—3 m. altus. Rami hornotini striati et canoso-puberuli. Folia simplicia, petiolis puberulis 2—6 mm. longe petiolata, ovata vel lanceolata, basi cordata, apice obtusa vel breviter rotundata et mucronata, mucrone reflexo, 3—6,5 cm. longa et 2—4 cm. lata, nervo medio supra impresso, inferne ex sulco prominulo, lateralibus utroque latere 5—8, in dentes subrecurvos excurrentibus, supra impressis, subtus valde prominentibus, utrinque densissime et prominenter reticulato-venosis, supra ad nervum medium resinoso-punctata et breviter adpresse pilosa, subtus in axillis nervorum flavo-strigillosa et ad nervos sparse pilosa vel glabra, inter nervos resinoso-granulata, margine acute et remote denticulata, coriacea. Thyrsi axillares et terminales racemosi, 1—1,5 cm. longi, pauci-(10—15-)flori. Pedunculus 3—8 mm. longus, striatus, breviter puberulus, flores in axillis bractearum 2—5, subsessiles vel usque ad 2 mm. longe pedicellati. Sepala suborbicularia, 1—1,2 mm. longa, rotundata, dorso puberula, intus glabra; petala 1,5 mm. longa, lamina ipsa ovata, basi truncata et longe stipitata, antice emarginata; filamenta 1,5—2 mm. longa, petalis breviter superata, puberula, antherae ovatae. Fructus non visus.

Holotypus: Cuba. Prov. Oriente: Sobre los farallones de la Abra de Yumuri, Baracoa. Leg.: H. Alain, J. Acuña et Ramos 7695! 16. jan. 1960. SV! isotypus: SV!

— Ibidem, M. López Figueiras 28. jul. 1960. UO 2320!

Obs.: *T. cubensi* Radlk. affinis, quae a specie nostra foliis basi rotundatis, nervis lateralibus utroque latere 7—10 utrinque prominentibus, inflorescentiis usque ad 3 cm. longis, subsessilibus, amentiformibus dense multifloris, floribus duplo majoribus sepalis ovatis 1.5 mm. longis, petalis obovatis, apice rotundatis, basi attenuatis, 3 mm. longis, filamentis petalis brevioribus omnino differt.

Thouinia hypoleuca Borhidi sp. n.

Frutex vel arbor parva, 3—5 m. alta. Rami hornotini dense pubescentes, vetustiores grisei, glabri. Folia 3-foliolata, 3—5 cm. longe petiolata, petiolis longe striatis, albo-tomentosis vel glabrescentibus suffulta. Foliola media 1/4—1/5 parte majora quam lateralia, late elliptica vel lanceolata, utrinque aequaliter angustata, apice breviter acuminata, basi cuneata, 5—9 cm. longa et 2,5—5 cm. lata, nervo medio lateralibusque utroque latere 9—12 supra hirtulis et profunde impressis, subtus carinato-prominentibus, utrinque densissime et prominenter reticulatis, lamina supra brunnea, nitida et mucigera, subtus ad nervos longe et dense albo-tomentosa vel hirsuta, in axillis non vel obscure barbata, sub pube inter nervos nitida et glabra, margine satis dense mucronato-dentata, plerumque valde revoluta, subcoriacea vel coriacea. Thyrsi laterales, multiflori, sub anthesi erecti, albo-strigillosi vel hirsuti. Bracteae obovatae, hirtulae. Pedicelli 2—2,5 mm. longi, 0,2—0,3 mm. lati; sepala 4, obovata, 2 mm. longa, 1 mm. lata, membranacea, extus albo-strigosa, intus glabra; petala 4, orbiculari-obovata, 1,5—2 mm. longa, basi stipitata, extus puberula, intus ad apicem stipitis barbata. Stamina 1,5 mm. longa, filamenta glabra, antherae ovatae, 0,5 mm. longae. Ovarium villosum, styli 3, recurvi, basi strigosi. Fructus obovato-ellipticus vel oblongo-obovatus, 1 cm, longus, breviter pilosus.

Holotypus: Cuba. Prov. Oriente; Mesa de Lindero entre Gran Tierra y Maisi, sobre rocas calcareas áridas. Leg.: H. Alain et M. López Figueiras 30. dec. 1959. (Al. 7038) SV!, isotypus: SV!

Specim. exam.: Oriente: Jauco abajo, manigua costera; leg.: H. León 11876!; — Farallón del Lindero, Maisi; leg.: H. León et Marie-Victorin 17174!; — Maisi, Baracoa; leg.: M. Bermudez (León 17491)!

Obs.: *T. maëstrensi* Lippold affinis, quae foliis minoribus, apice obtusis vel rotundatis, 6–8-nervatis, sparse et obtuse denticulatis, in axillis nervorum barbatis, floribus 5-meris, petalis sepala superantibus, filamentis pilosis abunde differt.

Fam.: **Rhamnaceae**

Rhamnidium brevifolium Borhidi sp. n.

Frutex; ramuli teretes, juniores glabri, nigro-striati. Stipulae interpetiolares triangulari-lanceolatae, dorso binerves, apice brevissime bidentatae, 1–1,5 mm. longae. Folia opposita 4–8 mm. longe petiolata, elliptica vel suborbicularia, basi obtusa vel truncata, brevissime mucronulata, 2–3,8 cm. longa et 1–2 cm. lata, nervo medio supra anguste impresso, lateralibus utroque latere 5–8 sub angulo 30–50° abeuntibus, utrinque prominulis et dense anastomosanti-reticulatis, reticulo venarum supra prominulo, subtus impresso, margine integra, undulato-recurva, supra nitida, viridia et irregulariter prominenti-punctata, subtus brunnea, opaca, minute et frequenter obsolete nigropunctata, chartacea. Inflorescentiae axillares, pruinosae, 2–4-florae, 1–1,5 cm. longae, 4–6 mm. longe pedunculatae, bracteae valde caducae; pedicelli 3–6 mm. longi, bracteolae triangulari-lanceolatae, longe acuminatae, acutae, 0,5 mm. longae. Calyx 4 mm. longus, tubus 2 mm. longus, pruinosus, glaber, lobi 5, tubo aequilongi, triangulari-ovati, apice acuti, crasse carnosi, intus longitudinaliter carinati, utrinque glabri. Petala 5, obovata vel spathulata, apice truncata et emarginata vel minute denticulata, basi breviter unguiculata, 1 mm. longa. Stamina 5, petalis opposita, filamenta 0,8–1 mm. longa, antherae 0,2–0,3 mm. longae, ovatae, apice apiculatae, supra basim dorsifixae. Ovarium obovatum, biloculare, 2 mm. longum, lateraliter compressum, dissepimentum completum. Ovula solitaria in quoque loculo. Discus annularis carnosus. Stylus 0,7–0,8 mm. longus, crassus, apice truncatus.

Holotypus: Cuba. Prov. Oriente: Charrascal de Pinales de Peña Prieta, La Magdalena, Toa; alt. aprox. 650–700 m.s.m. Leg.: H. Alain 3478; 20. jul. 1953. SV!

Obs.: *R. sulcinervi* Urb. affinis, quod foliis coriaceis 2—4-plo majoribus, superne angustatis, nervis lateralibus utroque latere 9—11, sub angulo 35–40° abeuntibus, parallelis, pedicellis fructiferis 2—3 mm. longis optime differt.

Karwinskia angustata Borhidi et Muñiz sp. n.

Frutex; rami hornotini teretes, nigrescentes, glabri. Stipulae lanceolato-subulatae 2 mm. longae, glabrae. Folia alterna, 3–4 mm. longe petiolata, lineari-lanceolata, apice longe angustata, acuta vel obtusiuscula, mucronata, basi obtusa vel rotundata, 5–11 cm. longa et 0,7–1,2 cm. lata, nervo medio supra impresso, subtus prominenti, lateralibus utroque latere 10–16, apicem versus arcuatis, et utrinque tenuiter prominulis, ante marginem conjunctis et reticulatis, lamina supra nitida, olivacea, subtus opaca, pruinoso-glaucescens utrinque glabra, supra punctis prominulis, subtus nigrescentibus obsoletis praedita, margine recurva, minute undulata, chartacea. Cymae umbellatae axillares 0,5–1,5 mm. longe pedunculatae, glabrae. Flores sessiles vel 1–2 mm. longe pedicellati, bracteolae 2, membranaceae, 1,5–2 mm. longae, ovatae vel lanceolatae, deciduae. Calyx 2 mm. longus, glaber, glauco-pruinosus, tubus 1 mm. longus; lobi triangulares, acuti, 1 mm. longi. Petala late ovata, 0,3

mm. longa et 0,5 mm. lata, brevissime stipitata, apice profunde excisa, medio puncto nigro ornata. Stamina 5, filamenta in sinus disci inserta, brevissima, antherae ovatae, 0,4—0,5 mm. longae; discus nigropunctatus, ovarium ovoideum, leviter 4-lobatum, glabrum, 2-loculare; ovula in quoque loculo 2.

Holotypus: Cuba. Prov. Pinar del Rio: Sierra del Rosario; Loma Pelada, Buena Vista, Cayajabos. Leg.: H. León 13825!, 23. mart. 1929. SV!

Obs.: *K. rocanae* (Britt. et Wils.) Urb. affinis, quae ramis hornotinis cinerascenti-puberulis, foliis 6—8 mm. longe petiolatis, oblongo-ellipticis, 7—10 cm. longis et 2—3.5 cm. latis, apice rotundatis vel obtusis, subtus sparse pilosis differt.

Fam.: **Clusiaceae**

Rheedia L.

Clave para las espécies cubanas:

1 a Hojas fuertemente revolutas 2
b Hojas planas o con el margen recurvo, no revoluto 3
2 a Ramitas trígonas, ápice de las hojas agudo, los nervios laterales 14—17 pares, salen en un ángulo casi recto .. 1. **R. polyneura** Urb.
b Ramitas cilíndricas, ápice de las hojas obtuso u redondeado, nervios laterales 7—10 pares, salen en un ángulo de ±45° .... 2. **R. revoluta** Urb.
3 a Hojas obovadas, mas anchas en el tercio superior .... 3. **R. cincta** Urb.
b Hojas aovadas, lanceoladas u oblongas 4
4 a Hojas de 3—9 cm., aovadas a oblongas 5
b Hojas de 1—4 cm., lineales, lineal-lanceoladas, oblongo-lanceoladas a oblongo-oblanceoladas 8
5 a Pedicelo corto 6
b Pedicelos axilares de 1.5 cm. de largo, pecíolo de las hojas de 3—5 mm. de largo ..... 4. **R. bakeriana** Urb.
6 a Hojas aovado-elípticas; redondeadas a retusas en la base 7
b Hojas oblongo-lanceoladas de 4—6 cm., obtusas o agudas en la base ..... 5. **R. brevipes** Britt.
7 a Fruto globoso de 8—15 mm. in diámetro ... 6. **R. aristata** Griseb.
b Fruto elipsoidal de 3 cm. de largo .. 7. **R. elliptica** Wr. ex Sauv.
8 a Pedicelos de 1—5 cm. de largo 9
b Pedicelos de 2—5 mm. de largo 11
9 a Hojas concavas sin nervios aparentes en el haz .... 8. **R. ophiticola** Borhidi
b Hojas planas, nervios prominentes en ambas caras 10

10 a Hojas oblanceoladas u oblongas, la base aguda .....
..... 9. **R. moaensis** Bisse
b Hojas aovado-lanceoladas a lanceo-lineales, la base obtusa o brevemente aguda ..... 10. **R. ruscifolia** Griseb.
aa Hojas aovado-lanceoladas, la base obtusa .....
..... 10/a. var. **ruscifolia**
bb Hojas lanceo-lineales, la base brevemente aguda .....
..... 10/b. var. **linearis** Borhidi
11 a Hojas sin nervios aparentes en el haz y sin nervios laterales conspicuos en el envés. Fruto de 1—1.5 cm. de diám .....
..... 11. **R. fruticosa** Wr. ex Griseb.
b Hojas con nervios laterales prominulos en ambas caras. Fruto de 2—2.5 cm. ..... 12. **R. cubensis** Borhidi

Rheedia ophiticola Borhidi sp. n.

Frutex ramosissimus, 1—3 m. altus; ramuli 3—4-goni glabri. Folia opposita vel 3—4-natim verticillata, 1—3 mm. longe petiolata, lanceolato-linearia vel linearia, basi cuneata, apice longe acuminata et aristato-pungentia, 1—2 cm. longa et 2—4 mm. lata, supra concava et avenia, subtus nervo medio crasse prominenti, lateralibus 10—14 ± rectangulariter patentibus, leviter prominulis, supra nitida, viridia, subtus opaca, in sicco brunnescentia, glabra, margine plana, rigide coriacea. Flores ad ramos laterales multi, 1—2,5 cm. longe pedicellati. Pedicelli axillares 1—2, tenues, triquetri, foliis ± aequilongi. Sepala 2, valvares, triangularia, apice acuta, dorso carinata, basi connata; petala 4—5, orbiculari-ovata, valde convexa, dorso carinata et nervosa, exteriora 2, lateraliter 1 lobulo dentiformi suffulta, 2 mm. longa et 3 mm. lata; stamina 12—20, ovarium globosum, stigma subsessile, 4-lobatum. Bacca globosa, nitida, 2 cm. in diam., 2-sperma.

Holotypus: Cuba. Prov. Oriente; Aserrio de Moa. Leg.: H. CLEMENTE, H. CHRYSOGONE et H. NESTOR (CLEMENTE 4325!) 25. jul. 1945. SV!

Specim. exam.: CLEMENTE 5514! Bajada al camino del Coco: Mina Franklyn, Moa; leg.: CLEMENTE, LEÓN et NESTOR 20. jul. 1947. — CLEMENTE 6872! Cananova, leg.: CLEMENTE, ALAIN et CHRYSOGONE, jul. 1949. — LEÓN 23244! Moa, jul. 1947. — SV 11105! Moa; leg.: Mrs. BUCHER — LEÓN 23246! Playa de Moa. Leg.: LEÓN et CLEMENTE 22. jul. 1947. — CLEMENTE 4116! Aserrio del Moa; leg.: CLEMENTE et ALAIN 17. jul. 1944. — LEÓN 21150! Cerro de Miraflores de Cananova; leg.: LEÓN et MONTERO jul. 1942. — LEÓN 20170! Loma de Jicotea, Sur de Moa; leg.: LEÓN et CLEMENTE 22. jul. 1942.

Obs.: Habitu *R. fruticosae* Wr. ex Griseb. affinis, quae foliis non venosis, ramulis 4—5-gonis, floribus breviter pedicellatis, pedicellis foliis multo brevioribus clare discrepat. Proxima *R. ruscifolia* Griseb., foliis ovato—lanceolatis, supra nervis bene prominentibus, floribus 2—4 cm. longe pedicellatis, pedicellis folia manifeste superantibus differt.

Rheedia ruscifolia Griseb. var. **linearis** Borhidi var. n.

Frutex usque ad 4—5 m. altus; a typo differt: foliis lancelato-linearibus, 1,5—3,5 cm. longis et 3—6 mm. latis, magis coriaceis.

Holotypus: Cuba. Prov. Oriente: Sierra del Cristal, in fruticetis serpentinosis montis Saca Lengua, alt. 650—700 m.s.m.; leg.: A. Borhidi, M. Vales et Ramóna Oviedo 11. apr. 1976. SV! isotypus: Bp!

Specim. exam.: Alain 5870! Sierra del Cristal: Rio Miguel; leg.: Acuña, Alain et M. López Figueiras. — Alain 7921! Sierra de Nipe: Cayo Sabinas al NE de la Loma Mensura in alt. 750 m.s.m.; leg.: Acuña et Alain. — López Figueiras 1888! Sierra de Nipe: Arroyo Canapu, Cayo Rey. — López Figueiras 2858! Sierra de Nipe: Pinal Colorado, Cayo Rey.

Rheedia cubensis Borhidi sp. n.

Frutex ramosissimus 1—3 m. altus; ramuli 4—6-goni, glabri, in axillis rosulato-foliosi, foliis 4—6-natim verticillatis. Folia lanceolato-linearia vel linearia, 1—3 mm. longe petiolata, basi breviter angustata, apice longe subulato-acuminata, 2—3 mm. longe mucronato-aristata, 1—2,3 cm. longa et 2—4 mm. lata, concava, nervo medio supra inferne valde prominenti, supra medium applanato, subtus crasse prominenti, lateralibus utroque latere 12—18, sub angulo 40—50° patentibus utrinque manifeste prominulis, lamina supra nitida, viridis, subtus flavicans, opaca, rigide coriacea. Pedicelli bacciferi solitarii, subsessiles vel 2—4 mm. longi, folio multo breviores. Baccae 2—2,5 cm. longae bispermae.

Holotypus: Cuba. Prov. Las Villas: Sabanas de Motembo; leg.: H. León et A. Loustalot (León 9320!) 9—10 aug. 1920. SV!

Specim. exam.: León 2933! Prov. Habana: Loma de Coca, Campo Florido; leg.: León 9. apr. 1912. — Ibidem Borhidi 672!, leg. A. Borhidi et O. Muñiz 19. sept. 1969. — Prov. Matanzas: León 14806! Loma de los Botinos, 28. mart. 1931. — Espinal de Canasi, Acuña 24268 SV!

Obs.: *R. fruticosae* Wr. ex Griseb. (e Prov. Pinar del Rio: Cajalbana) affinis, quae foliis supra enervibus, subtus nervis lateralibus absentibus, baccis minoribus differt.

Fam.: **Flacourtiaceae**

Samyda campanulata Borhidi et Muñiz sp. n.

Frutex vel arbor parva. Rami hornotini ferrugineo-hirsuti. Stipulae lineares, 2—3 mm. longae. Folia distiche alterna, 2—4 mm. longe petiolata, ovata vel obovata, 3—8 cm. longa et 2—4,5 cm. lata, basi obtusa, rotundata vel subcordata, apice obtusa vel brevissime apiculata, nervo medio supra in sulco prominulo, subtus solemniter prominente, lateralibus utroque latere 7—10, utrinque densissime reticulato-conjunctis, supra prominulis et pilis basi tuberculatis copertis, subtus bene prominentibus et longe ferrugineo-hirsutis, margine breviter serrulata vel subintegra, tenuiter revoluta, corriacea. Flores in axillis solitarii, nutantes. Pedicelli 3—5 mm. longi, ferrugineo-hirsuti. Calyx campanulatus, usque ad 1,2 cm. lon-

gus; tubus 5—6 mm. longus, sub lobis 8—9 mm. latus, lobi late ovati, 5—6 mm. longi, utrinque rufo-puberuli. Stamina 9—10, gamosepala; filamenta connata, pars libera triangulari-subulata, apice acuta, 1,2—2 mm. longa. Antherae suborbiculares, e tubo exsertae. Stylus glaber, 6—7 mm. longus, utroque extremo dilatatus. Stigma capitatum, brevissime 2—10-lobum Fructus globosus, 3-locularis, usque ad 1,5 cm. in diam., extus villosus.

Holotypus: Cuba. Prov. Oriente: manigua costera, Renté, Santiago de Cuba; leg.: H. CHRYSOGONE 1982!, aug. 1951. SV!

Specim. exam.: CLEMENTE 5330, Ciudamar, Santiago de Cuba, mai. 1947. — CLEMENTE 3680! Carretera del Morro, Santiago de Cuba, jun. 1944. — LEÓN 17267! Mesa del Chivo, Maisi; Oriente. 25. aug. 1939. — Ibidem, LEÓN 18602! dec. 1938.

Obs.: *S. dodecandrae* Jacq. affinis, quae floribus fasciculatis, tubo calycis angusto, lobis longiore, filamentis apice truncatis, in tubo insertis bene differt.

Samyda subintegra Borhidi et Muñiz sp. n.

Frutex 1 m. altus. Rami hornotini ferrugineo-hirsuti. Stipulae lineares, 1 mm. longae, Folia distiche alterna, 1—2 mm. longe petiolata, elliptica vel oblongo-ovata vel obovata. 3—7 cm. longa et 1,5—3 cm. lata, basi obtusa vel rotundata, leviter obliqua, apice obtusa, et brevissime mucronata; nervo medio supra impresso, subtus arcte prominente, lateralibus utroque latere 7—9, arcuatis et ante marginem recurvatis, utrinque reticulatis, supra omnibus impressis, subtus prominentibus, lamina supra flavo-hirsuta et minutissime rugulosa, subtus ad nervos dense patenti-hirsuta, margine integra vel obsolete denticulata, chartacea. Flores in axillis foliorum 1—3, brevissime pedicellati. Calyx infundibuliformis 1,2—1,5 cm. longus, tubus calycis cylindricus, 6—7 mm. longus et 3—4 mm. in diam.; lobi obovati, tubo aequilongi, utrinque fulvo-pubescentes. Stamina 10, filamenta in tubum glabrum connata, gamosepala, pars libera ± 1 mm. longa, plana, apice truncata, antheris aequilata. Antherae oblongae, e tubo calycis exsertae. Stylus glaber, utroque extremo dilatato, stigma capitatum. Ovarium villosum, 3-loculare.

Holotypus: Cuba. Prov. Camagüey: Loma de caliza, Pastelillo, Nuevitas, Leg.: LEÓN 23385!, jul. 1948. SV!

Obs.: *S. dodecandrae* Jacq. affinis, a qua foliis chartaceis, nervis lateralibus supra impressis, lobis calycis tubo aequilongis, obovatis, antheris oblongis differt. Verisimiliter *Samyda dodecandra* Jacq. typica in Cuba non occurrit.

Fam.: **Thymelaeaceae**

Daphnopsis angustifolia Wr. in Griseb. var. **nipensis** Borhidi et Muñiz var. n.

A typo differt: foliis obovatis vel oblanceolatis, 1,5—4 cm. longis et 0,6—1,5 cm. latis, pistillodio ampulliformi 1,5 mm. longo.

Holotypus: Cuba. Prov. Oriente; Sierra de Nipe, Pinares de Mayari; leg.: M. LÓPEZ FIGUEIRAS (UO 917), 27—31. mai. 1960. SV! — Ibidem UO 941 SV!

Fam.: **Symplocaceae**

Symplocos moaënsis Borhidi sp. n.

Frutex vel arbor parva; rami hornotini angulato-striati, glaberrimi. Folia oblongo-elliptica vel oblongo-ovata, apice obtusa vel brevissime emarginata, basi cuneata et in petiolum protracta, petiolis 2—4 mm. longis glabris suffulta, 5,5—9 cm. longa et 2—3,5 cm. lata, nervo medio supra impresso, subtus prominenti, lateralibus utroque latere 6—8, utrinque prominulis vel supra obsoletis et subtus reticulato-venosis glaberrimis, lamina supra flavo-viridis, plerumque brunneo-maculosa, subtus flavicans, utrinque lucida et glabra vel rariter sparse adpresseque strigulosa, margine integra, coriacea. Inflorescentiae axillares, glomeratae vel plerumque breviter racemosae, ferrugineo-strigillosae, 1—6-florae. Pedunculus 0—3 mm. longus, pedicelli plerumque nulli; bracteae late ovatae, 0,2—0,3 mm. longae, ferrugineo-strigosae. Flores 3—4 mm. longi. Calyx 2—2,5 mm. longus, tubus 1—1,5 mm. longus, glaber, lobi 5, ovati, valvati, apice obtusi, 1—1,2 mm. longi, extus ferrugineo-strigillosi. Corolla 2,5—3 mm. longa, glabra, tubus 1—1,2 mm. longus, lobi 5, imbricati, late ovati, 1,8—2 mm. longi, concavi, apice rotundati. Stamina 15—18, basi tubi corollae 3—4-natim coalita adnata, filamenta filiformia, inaequilonga. Antherae subdidymae, 0,3—0,4 mm. longae. Ovarium 1,5—2 mm. longum, semi-inferum, vertice longe ferrugineo-hirsutum, biloculare; ovula 2 in quoque loculo. Stylus 1 mm. longus, glaber; stigma breviter capitatum.

Holotypus: Cuba. Prov. Oriente; Mina Iberia, Taco Bay, Baracoa; leg.: E. Del-Risco 27167 SV! —

Specim. exam.: Prov. Oriente, Moa; Aserradero del km. 26, La Melba; leg. E. Del-Risco 28. mart. 1972. 27442 SV! et 27506 SV!

Obs.: *S. ciponimoidi* Griseb. affinis, quae ramulis villosis, foliis subtus plerumque ad nervos sericeo-strigosis, corolla sericea, staminibus 25, bene differt.

Fam.: **Borraginaceae**

Cordia suffruticosa Borhidi sp. n.

(**C. stenophylla** Alain p. p. non **C. angustifolia** (Vent.) Roem. et Schult.)

Suffrutex ramosissimus, 30—80 cm. altus. Rami hornotini teretes, striati, glandulosi et pilis sursum orientatis ± adpressis sparse strigillosi vel setulosi. Folia lineari-obovata vel oblongo-obovata, apice rotundata et plerumque breviter excisa, basi cuneata, 1—1,5 mm. longe petiolata, 0,8—3,5 cm. longa et 2—5 mm. lata, nervo medio supra impresso, subtus prominenti, lateralibus utroque latere 5—7, supra impressis, subtus prominulis, lamina in sicco nigrescens, supra dense tuberculato-rugulosa, scabra et minutissime glandulosa, subtus ad nervos sparse adpresse setulosa, inter nervos tomento delicatissimo viridi et glandulis minutis lucidis obtecta, margine leviter crenulata vel undulata, tenuiter recurva, sparse strigosa. Influrescentia spicata, pauciflora, terminalis, usque ad 1 cm. longa. Pedunculus 1—2 mm. longus, pube ramorum suffultus. Calyx campanulatus, 2,5—3 mm. longus, tubus 1,5—2 mm. longus, superne ampliatus, nervosus, extus glandulosus et sparse strigillosus, lobi 4(—5), triangulares, 1 mm. longi, acuti, apice breviter et crasse mucronati. Corolla 4—5 mm. longa, tubus 3—3,5 mm. longus, 10-nervosus, intus ad nervos sub filamentis strigillosus, lobi 5, reflexi, 1—1,5 mm. longi, extus minutissime glandulosi, intus glabri. Stamina 5, filamenta medio tubi affixa, 1—1,2 mm. longa, glabra. Antherae versatiles, in fauce tubi insertae. Stylus 2 mm. longus. Fructus purpureus, lucidus, calyce inclusus, 3 mm. in diametro.

Holotypus: Cuba. Prov. Oriente: in fruticetis serpentinosis montis Cerro Galano prope La Palma, Holguin. Leg.: A. Borhidi, R. Capote et Ramona Oviedo 25. sept. 1975. SV 27751!; isotypi: SV 27752! et Bp!

Specim. exam.: WRIGHT 3114 (e Cuba Orientali, verisimiliter e Sierra de Nipe)! — M. LÓPEZ FIGUEIRAS 2508! Sierra de Nipe: charrascales de la Cueva; 25. febr. 1956.

Cordia holguinensis Borhidi et Muñiz sp. n.

Frutex 1—2 m. altus. Rami hornotini teretes, setis patentibus et tomento albido atque glandulis sessilibus intermixtis setoso-pubescentes, vetustiores obscure cinerei, glabri, minute striati. Folia petiolis 5—10 mm. longis et 1—1,5 mm. latis suffulta, oblongo-ovata, oblongo-elliptica vel lanceolata, basi cuneata, apice obtusa, plerumque sub medio latissima, 3—7 cm. longa et 7—15 mm. lata, nervo medio cum lateralibus utroque latere 8—11 supra impressis, subtus prominentibus, utrinque reticulato-anastomosantibus, margine undulato-crenulata et tenuiter revoluta, lamina supra bullescens, setuloso-scabra, subtus ad nervos patenti-strigillosa, inter nervos tomento cinereo-viridi pulverulenta, et glandulis lucidis sessilibus utrinque glandulosa, chartacea vel subcoriacea, rigida. Inflorescentiae terminales vel pseudo-laterales, cylindraceo-spicatae, apicem versus leviter dilatatae. Pedunculus 2—5 cm. longus, spica ipsa usque ad 8 cm. longa, dense patenti-hirsuta et glandulosa. Calyx sub anthesi 4—5 mm. longus, extus strigosus et glandulosus, intus glaber; lobi 5, tubo breviores, triangulares, acuti, inaequimagni, 1—1,5 mm. longi. Corolla 5 mm. longa, extus glabra, tubus leviter turbinatus, 3,5—4 mm. longus, superne 3,5—4 mm. latus, intus ad basim filamentorum pubescens; lobi 5, oblongo-triangulares, apice obtusi vel acuti, 1,5—2 mm. longi, sub anthesi valde reflexi. Stamina inaequilonga, supra medio tubi adnata, filamenta breviora 0,7 mm. longa, longiora 2,5 mm. longa, basi puberula. Antherae dorsifixae, ellipticae, 1 mm. longae. Fructus globosus, purpureus, glaber, 4—5 mm. in diametro; in calyce non inclusus.

Holotypus: Cuba. Prov. Oriente; in fruticetis serpentinosis ad Ceja de Melones prope opp. Holguin. Leg.: A. BORHIDI, R. CAPOTE et RAMONA OVIEDO 24. sept. 1975. SV! isotypus: Bp!

Specim. exam.: Borhidi 8185; Prov. Oriente, La Tinajita, prope opp. Gibara. Leg.: A. BORHIDI, O. MUÑIZ, E. DEL-RISCO et A. LÓPEZ 17. jul. 1970.

Obs.: *C. cinerascenti* A.DC. affinis, quae foliis eglandulosis, inflorescentia puberula, non glanduloso-strigosa, calyce 2 mm. longo, fructibus 3 mm. in diam. calyce inclusis satis differt.

Fam.: **Verbenaceae**

Callicarpa moana Borhidi et Muñiz sp. n.

Frutex 1—2 m. altus. Rami juniores obtuse 4-angulati, sparse et breviter spinuloso-tuberculati, pilis multiradiatis ferrugineis densissime obtecti, vetustiores teretes. Folia petiolis 8—10 mm. longis, 3-costatis, supra canaliculatis, basi manifeste dilatatis suffulta, ovata vel elliptica, apice breviter acuminata et mucronato-acuta, basi sensim angustata et obtusiuscula, 3—6 cm. longa et 1,5—3 cm. lata, medio latissima, nervis lateralibus utroque latere 6—8, sicut medio supra impressis, subtus bene prominentibus, utrinque dense areolato-reticulata, reticulo supra profunde impresso, subtus crassiuscule prominenti, margine plana et apicem versus brevissime crenulata, lamina supra bullata et breviter albo-setulosa, nigra, subtus pilis multiradiatis ferrugineis densissime tomentosa, sub tomento eglandulosa, subcoriacea. Inflorescentiae axillares cum pedunculo 1—1,5 cm. longo 2,5—3 cm. longae, corymbiformae, dichotome ramificatae. Bracteae lineares infimae 4—5 mm. longae, superiores breviores. Pedicelli vix 0,5 mm. longi. Calycis tubus breviter turbinatus 1—1,5 mm. longus, stellato-pilosus. Cetera non visa.

Holotypus: Cuba. Prov. Oriente; Sierra de Moa; charrascales y pinares en alt. aprox. 800 m.s.m. Leg.: H. ALAIN 3377! 25—26. jul. 1953. SV!

Obs.: *C. areolatae* Urb. affinis, quae foliis oblanceolatis, supra medium latissimis, 0.8—1.5 cm. longis, brevius petiolatis, supra glabris, inflorescentiis brevioribus, atque floribus fructibusque (?) differt.

Callicarpa toaënsis Borhidi et Muñiz sp. n.

Frutex; rami hornotini obtuse 4-anguli, sparse et breviter spinuloso-tuberculati, pilis multiradiatis ferrugineis densissime obtecti, vetustiores teretes. Folia petiolis 3—7 mm. longis, convexis, supra esulcatis, 1—1,5 mm. latis suffulta, lanceolata vel oblanceolata, apice acuminata, basi longe cuneata, 2,5—6,5 mm. longa et 1—2,2 cm. lata, nervis lateralibus utroque latere 6—8, sicut medio supra impressis, subtus bene prominentibus, utrinque dense areolato-reticulatis, reticulo supra impresso, subtus crassiuscule prominenti, lamina margine plana et superne irregulariter crenulato-denticulata, supra bullescens et dense albostrigosa, subtus pilis multiradiatis ferrugineis densissime tomentosa, sub tomento inter venas dense glandulosa, coriacea, vel subcoriacea. Inflorescentiae axillares, dichotome cymoso-corymbosae, 1—1,5 cm. longe pedunculatae, pedunculis tuberculatis et ferrugineo-floccosis suffultae, 2—3 cm. longae. Bracteae inferiores lineares, 3—4 mm. longae. Pedicelli 1,5—2,5 mm. longi, stellato-puberuli et glanduloso-pilosi. Calycis tubus cupulatus, obsolete dentatus vel truncatus, 1,5 mm. longus, dense ferrugineo stellato-hirsutus et pilis glandulosis obsitus. Corolla 2,5 mm. longa, extus glandulosa. Fructus depresse globosus, 3—4 mm. longus et 3—5 mm. latus, dense glanduloso-hirsutus.

Holotypus: Cuba. Prov. Oriente; Palenquito de Yateras en alt. aprox. 550 m.s.m. Leg.: H. ALAIN 3077! 20. jul. 1953. SV!; isotypus: SV!

Specim. exam.: ALAIN 3742! Cuba, Prov. Oriente, Cumbre del Pico Galano, Sierra de Frijol, La Alegria, Toa; alt. aprox. 1050 m.s.m. 1. jan. 1954 — SV 26665! Prov. Oriente; Cupeyal de Norte. Leg.: V. SAMEK, mart. 1968.

Obs.: Ex affinitate *C. leonis* Mold., quae foliis ellipticis, margine regulariter crenulatis, subtus sparse stellato-tomentosis, pedunculis multo brevioribus, inflorescentiis pilis glandulosis carentibus differt.

Vitex guanahacabibensis Borhidi sp. n.

Arbor parva usque ad 3—4 m. alta. Rami hornotini 4-anguli, griseo-puberuli, vetustiores glabri. Folia 3-foliolata, 2,5—6,5 cm. longe petiolata, foliola sessilia vel centralia plerumque 2—4 mm. longe petiolulata, lanceolata vel oblongo-lanceolata, antice longe acuminata vel caudata, basi cuneata vel obtusiuscula, centralia 5—12 cm. longa et 1,7—3 cm. lata, nervo medio supra impresso, subtus prominenti, lateralibus utroque latere 10—14, arcuatis et ad marginem conjunctis, utrinque tenuiter anastomosanti-reticulatis, lamina supra brunnea vel nigrescens, initio dense impresso-glandulosa, postremo glandulis dejectis impresso-punctata, glabra, subtus adpresse cinereo-tomentosa, sub tomento eglandulosa, margine integra, revoluta, chartacea. Inflorescentiae axillares, paniculatae, 4—5 cm. longae. Pedunculus 2—3 cm. longus, puberulus. Calyx 1,5—2 mm. longus, remote et brevissime 4-dentatus vel truncatus. Corolla 4-lobulata, extus puberula. Fructus globosus 3,5—4 mm. longus, glaber.

Holotypus: Cuba. Prov. Pinar del Rio. Litoral Sur de la Peninsula de Guanahacabibes. Leg.: J. ACUÑA et F. ZAYAS jul. 1955. 19938 SV!, isotypi: SV!

Specim. exam.: Peninsula de Guanahacabibes: Punta Holandés. Leg.: A. Borhidi, R. Capote et M. Vales, 18. dec. 1974! — Peninsula de Corrientes, Guanahacabibes; Manigua costera. Leg.: H. Alain 6915! 22, dec. 1959.

Vitex acunae Borhidi et Muñiz sp. n.

Arbor parva; ramuli obtuse 4-anguli, griseo vel ferrugineo-puberuli, vetustiores glabri. Folia 3-foliolata, 3—7 cm. longe petiolata, foliola sessilia vel centralia 2—4 mm. onge petiolulata, ; lanceolata vel oblongo-lanceolata, apice longe acuminata, basi cuneata, lvel obtusiuscula, centralia 8—15 cm. longa et 3—6 cm. lata, lateralia minora; nervo medio supra impresso, subtus prominenti, lateralibus utroque latere 7—10 arcuatis, supra impressis et obsolete anastomosantibus subtus dense et crassiuscule prominenter reticulato-venosis, lamina supra in sicco brunnescens et sparse glandulosa, glabra, subtus tenuiter et adpresse cinereo-pulverulenta et dense flavo-glandulosa, postremo ad nervos sparse hirtula ceterum glabrescens vel glabra, glandulosa, margine integra vel apicem versus leviter denticulata, plana, chartacea. Inflorescentiae axillares, pedunculi petiolis ± aequilongi, puberuli. Panicula ipsa 4—6 cm. longa, ferrugineo-puberula et glandulosa. Calyx 2—2,5 mm. longus, breviter 4-lobatus, lobi apice mucronulati, semiorbiculares. Corolla 3—4 mm. longa, extus pulverulenta, 4-lobata. Fructus globosus vel obovatus 4,5—6 mm. longus, glaber.

Holotypus: Cuba. Prov. Pinar del Rio. Montes de la Peninsula de Guanahacabibes. Leg.: J. Acuña et F. Zayas 24. jul. 1955. 19936! SV; isotypi: SV!

Vitex praetervisa Borhidi sp. n.

Arbor parva vel fruticosa. Rami hornotini obtuse 4-anguli, ferrugineo-puberuli, vetustiores teretes, glabri. Folia 3-foliolata, 1,5—2,5 cm. longe petiolata, foliola sessilia, lanceolata vel oblanceolata, apice acuminata et plerumque acuta, basi cuneata vel obtusiuscula, centralia 2—4 cm. longa et 0,6—1,2 cm. lata, nervis supra anastomosantibus et areolato-impressis, subtus crassiuscule prominentibus et dense reticulatis, lamina supra in sicco brunnea vel nigrescens, sparse lepidota, mox glabra et plicatula, subtus dense cinereo-lanuginosa, sub tomento eglandulosa, margine integra, plana, chartacea. Inflorescentiae axillares, 1—2 cm. longae, 1—1,5 cm. longe pedunculatae, capituliformiter cymosae. Calyx 1,5—2 mm. longus, breviter 4-dentatus, glandulosus et glabrescens vel glaber. Corolla 2—2,5 mm. longa, 4-lobulata, extus glandulosa. Fructus obovatus, 4—5 mm. longus, glaber.

Holotypus: Cuba; Prov. Oriente; Cabo Cruz, sobre rocas calizas. Leg.: H. León 16336! 31. dec. 1935. SV!

Obs.: Citada erroneamente por Moldenke como *V. tomentosula* Mold.

Fam.: **Solanaceae**

Cestrum moaënse Borhidi et Muñiz sp. n.

Frutex. Rami teretes, pilis multiramosis rufis dense tomentosi, stricti. Folia 2—4 mm. longe petiolata, elliptica vel oblongo-elliptica, antice angustata, apice ipso obtusa, basi breviter rotundata vel subcordata, 3—7 cm. longa et 1,5—3 cm. lata, nervo medio supra impresso lateralibus utroque latere 5—7 arcuatis supra impressis, subtus omnibus prominulis, non reticulatis, lamina supra glabra, nigrescens, leviter bullata, nitida, subtus ad nervos sparse

stellato-pilosa, inter nervos rufo-punctata, margine valde involuta, rigide coriacea. Inflorescentiae axillares 1-florae et terminales 1—2-florae; pedunculo subnullo, usque ad 1—3 mm. longo, rufo tomentoso suffultae. Bracteae lanceolatae vel lineari-lanceolatae, crassae, tomentosae, 5—6 mm. longae; pedicelli 1—2 mm. longi, 1 mm. crassi, perfecte glabri. Calyx obovatus 4—5 mm. longus glaber, obsolete 5-nervis, lobi triangulares, apice mucronati et pilosi, tubo duplo breviores. Corolla non visa. Fructus globosus, nigrescens, glaber, 6 mm. in diametro.

Holotypus: Cuba. Prov. Oriente; Sierra de M*da*, in alt. 800 m.s.m. Leg.: H. ALAIN 25—26. jul. 1953. 3443 SV!

Obs.: *C. hirto* Sw. affinis, quod ramis ferrugineo tomentosis, foliis ovatis, longius petiolatis, membranaceis vel chartaceis densissime tomentosis, inflorescentiis capitatis 3—8-floris, pedunculis petiolo longioribus atque calycibus stellato-pubescentibus differt.

Cestrum buxoides Ekm. ex Urb. var. **lucens** Borhidi et Muñiz var. n.

A typo differt: foliis utrinque lucidis, calycibus 3,5—4,5 mm. longis, lobis triangularibus 5—8 mm. longis, tubo 5—5 1/2-plo brevioribus, margine denticulatis, corollae lobis 4 mm. longis, tubo 4—5-plo brevioribus, baccis subglobosis.

Holotypus: Cuba. Prov. Oriente; Charrascos de la Sierra de Moa, en alt. aprox. 800 m.s.m. Leg.: H. ALAIN 25—26. jul. 1953.; 3407, SV!

Specim. exam.: Ibidem, H. ALAIN 3313! 3321! 3345!

Obs.: Probablemente endémica de la zona alta de la Sierra de Moa.

Fam.: **Gesneriaceae**

Gesneria pallida Morton ex Borhidi et Muñiz sp. n.

Perennans, glaberrima, caule simplici, subnullo. Radix elongata, lignescens, parce ramosa. Folia ± reticulata, subsessilia, obovata, apice obtusa, vel brevissime acuta, basi auriculata et in petiolum protracta, 2,5—8 cm. longa et 1,5—3,5 cm. lata, margine irregulariter et remote crenulata, nervis supra tenuiter impressis, subtus prominulis, ante marginem arcuato-conjunctis et reticulato-venosis, membranacea. Pedunculus 1-florus, 1—2 cm. longus, supra basim prophylla bina lineari-obovata 3—6 mm. longa gerens. Calycis tubus breviter obovatus 3—4 mm. longus, lobi lanceolati vel triangulares, 1-nerves, tubo aequilongi. Corolla 20—25 mm. longa, pallide flava, claviformi-cylindrica, superne sensim ampliata, sub apice in statu compresso 3—4 mm. lata, lobis concoloribus, in statu compresso 7—8 mm. latis, 3—5 mm. longis, antice rotundatis, margine serrulatis, extus cum tubo puberulis vel tomentosulis. Antherae e tubo vix exsertae, stylus 15 mm. longus.

Holotypus: Cuba. Prov. Oriente; Pinares y cañadas al Norte de Yunque de Baracoa. Leg.: J. ACUÑA, H. ALAIN et RAMOS. 13. jan. 1960. ALAIN. 7609 SV!; isotypi: SV!

Obs.: *G.glandulosae* (Griseb.) Urb. affinis, quae caulibus foliisque dense glanduloso-villosis, calycis tubo purpureo-piloso, lobis purpureis et corollae

tubo atque garganta leviter contracto; taxon proximum, *G. cuneifolia* (DC.) Moq. et Sessé ssp. *obovata* (Griseb.) Borhidi foliis margine biserratis et leviter bullatis, lobis calycis ovatis, corolla purpurea differt.

Gesneria acunae Borhidi sp. n.

Perennans; caulis usque ad 4—5 cm. longus, villosus, lignescens. Folia rosulata, subsessilia, oblongo-oblanceolata, apice apiculata et plerumque acuta, basi angustata et in petiolum brevissimum et alatum protracta, 8—13 cm. longa et 2—3 cm. lata, utrinque dense, reticulato-venosa et ad nervos longe puberula vel postremo glabrescentia, leviter bullata, margine crenulato-serrata vel serrato-denticulata, membranacea vel subchartacea. Pedunculus 1—2-florus ± 1 cm. longus, resinosus. Prophylla lineari-subulata usque ad 1 cm. longa. Calycis tubus obconicus, leviter turbinatus, 2—3 mm. longus, puberulus; lobi calycis subulato-lanceolati 10—13 mm. longi, supra basim latissimi, 2 mm. lati, longe pilosi. Corolla 25—28 mm. longa, extus albo-puberula; tubo in sicco flavo, obconico, sub apice in statu compresso 7—9 mm. lato, lobis sanguineo-purpureis, margine flavis, superioribus semiorbicularibus infimo 8—10 mm. longo et lato. Stamina e tubo exserta, antherae oblongae, apice cohaerentes. Capsula 5—6 mm. longa, longe villosula.

Holotypus: Cuba. Prov. Oriente: sobre un paredón al Este del Yunque de Baracoa, alt. aprox. 300 m.s.m. Leg.: J. Acuña, H. Alain et Ramos, 14. jan. 1960. Alain 7541! SV; isotypi: SV!

Obs.: *G. shaferi* Urb. affinis, quae caulibus foliisque glabris, foliis 4—8 cm. longis, apice obtusis, calycis lobis lanceolatis, 5—7 mm. longis, glabris, corolla 17—20 mm. longa, tubo purpureo et lobis flavis, rubro-venosis abunde differt.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (3—4), pp. 321—354 (1976)

NICHE STUDIES ON SOME PLANT SPECIES OF A GRASSLAND COMMUNITY I

COMPARISON OF VARIOUS MEASUREMENTS

By

G. FEKETE,* I. PRÉCSÉNYI,** E. MOLNÁR,** and E. MELKÓ**

* BOTANICAL DEPARTMENT, NATURAL HISTORY MUSEUM, BUDAPEST
** BOTANICAL RESEARCH INSTITUTE, HUNGARIAN ACADEMY OF SCIENCES, VÁCRÁTÓT

(Received November 10, 1976)

This series of papers proposes an analysis of the niche-relations of the dominant-abundant species of a dry grassland. This first publication estimates the parameters of niche-overlap and of niche-breadth on the basis of various indices obtained from measurements taken with regard to two niche dimensions: soil moisture content, depth of maximum root mass; hereafter: root depth. The applied niche breadth indices and functions, respectively, are as follows: Evenness calculated on the basis of SHANNON's formula (H_i); COLWELL—FUTUYMA's formula (1971) based on SHANNON's formula ($C_{i,w}$); PIELOU's (1972) two formulas for the average breadth $h_i(b)$ and for the weighted breadth $u_i h_i(b)$; LEVINS's (1968) B_i. Overlap formulas: HORN's (1966) R_{hi}; WHITTAKER—FAIRBANKS's (1958) C_{hi}; LEVINS's (1968) α_{hi} and α_{ih} competition coefficients; the Euclidean distance (ORLÓCI 1967d); finally, the D-value. By means of the weights calculated with the COLWELL—FUTUYMA method, the basic values were transformed to the calculation of also other index values.

In both dimensions, the LEVINS-type B_i all other measurements estimated in the best way (judging from the rank correlations according to values). The different nature of the measurements is indicated by the fact that in many cases it is not the various weighted measurements which show agreement, but, for example, a weighted formula with a non-weighted one of other origin. As was expectable, PIELOU's weighted measurements showed sensitivity to the relative frequency of the species, while the measurement of COLWELL and FUTUYMA to the categories.

The overlap measurement R_{hi} of HORN gave a high value in much more of the cases than did the C_{hi} measurement. The average overlap value in the case of soil moisture content was the highest in *Festuca vaginata*, while the lowest in *Fumana procumbens;* in the case of the root depth, the average overlap value of *Thymus* sp. is the highest, and again that of *Fumana* is the lowest. According to the combinations of categories, *Festuca* stands at the beginning of the order, while *Fumana* stands at the end.

The niche-values, according to categories in combination, and also the community and species effects which can be read from the community matrix, are similar to the pattern shown by root depths.

Introduction

The amalgamation of the various niche conceptions (GRINNELL 1917, ELTON 1927, DICE 1952, CLARKE 1954, etc.) and the foundation of a general niche theory are due to HUTCHINSON (1957). The known theory — which characterizes and formulates the populations by means of "dimensions" indicated by (relevant) factors providing the conditions of their existence and

survival and by means of hyperspaces marked by the dimensions — originated in zoo-ecology. Its wide spread there has been supported by its concurrence and intertwining with competition theory.

The present survey does not lay claim to provide a complete picture of either the development of the niche theory, of the overwhelmingly zoo-ecological results of an experimental research adequate to the theory, mainly because there are satisfactory summaries available for the purpose (cf. MILLER 1967, LEVINS 1968, PIANKA 1972, VANDERMEER 1972, MAGUIRE 1973, COLWELL-FUENTES 1975, PIELOU, 1975). Our aim is to analyse some of the aspects and problems of the plant-ecological application of the niche conception.

It is surprising to what extent plant ecology has neglected the interpretation of niche relations of species to our very days. The position of the populations within the community on the environmental continuum, or, for example, life functions of shorter periods, or the distribution of the seasonal rhythm according to species on the time axis, were interesting for the ecologists in the majority of the cases not because of considerations like, for example, detecting how they make coexistence possible. A great number of traditional community-phenological descriptions are satisfied with confining themselves to a mere registration of the phenomenon examined and they do not even make an attempt to approach the various phenomena from an aspect of coexistence. The examination of intercommunity behaviour of the species studied from one of the aspects of habitat have ever been a more attractive field of research (WHITTAKER—LEVIN—ROOT 1973). (Here we think of the great number of works referring to the "ecological indicator" role of the species, according to which the species on the scale of habitats lie on the gradients of the various factors, thus distinguishing and indicating certain grades.) Phytocenology and the related applied sciences (among others the science of arboriculture) describe many interesting examples of phenomena which might be adequately discussed by means of the niche theory. Let us take, for example, the sharp segregation of tree species according to soil types on the northern boundary of the European deciduous forest zone. This is nothing but a niche question. The competition of linden, oak, and maple with the conifers on some sand or grave soil there is already in favour — as a result of the climatic background — of the latter trees; on the other hand, the conifers are excluded on a loess soil rich in nutrients.

The fundamental niche (the "virtual niche") of the niche theory is to be considered as pre-competitive (in the conception of the zoologist VANDERMEER, 1972, it is to be placed at the niche-breadth where the density dependence of the population is not yet operative, as against the so-called first partial niche which corresponds to the intraspecific competition). Unfortunately, plant-ecology is still rather far from having developed more or less uniform methods of studying the fundamental niche, for the very reason, for example, because it is more difficult for the population-biological view to gain ground in plant ecology than in zoo-ecology. Undoubtedly, simpler organisms (for example algae) are more ideal subjects to become familiar with the fundamental niche (cf. CASTENHOLZ 1968) than organisms of a higher order. Relatively simple experiments are also suitable for a comparison between fundamental and realized niches. An example of this is MOORE's work (1959), in which he presents the separation of the realized niches of two *Eucalyptus* species with similar fundamental niches; the results also represent the confirmation of PARK's *Tribolium* experiments on plant objects. The application of selective herbicides represents an advancement not only technically — the selective removal of competitiors — as, for example, the experiments of PUTWAIN—HARPER (1970) on related *Rumex* species. KRUCKEBERG (1954) examined serpentine plants on the basis of related principles. By elaborating and applying transplantation techniques, he pointed out that the fundamental niche of the serpentine species (in relation to soil factors) is wider than that of the co-existing non-serpentine species (cf., recently, WOODELL—MOONEY 1975); their ecological niche narrows down only under the effect of competitors. TADROS (1957) demonstrated the same on two species of a genus (*Emmeranthe*), one of which had a serpentine habitat. The analysis of such extreme ecological situations is obviously a fruitful task since the number of possible factors is reduced. Incidentally, the contrasting of the fundamental behaviour of the species of their precompetitive tolerance, with the ecological niche is a possibility which has hardly been exploited yet. Apparently,

the wide amplitudes of physiological tolerance do not in a number of cases imply the great breadth of the realized niche. The great tolerance of *Typha angustifolia* — in isolation — towards the wide scale of salt concentration solved in the soil is accompanied by weak competitive abilities; this is why the physiologically "generalist" plant becomes an ecological specialist of disjunct areas. This example is at the same time analoguous with that of the above serpentine species. On the other hand, a suitable physiological specialization —to saltless water — makes the related *Typha latifolia*, according to the experiments of McMillan (1959), though not an ecological generalist, still a species of wide range.

An important parameter of niche is the volume (niche breadth), and the overlap of niche, between two populations (Levins 1968). An increase in the overlap of niche would indicate the extent of the joint use of resources, the sharpening of the competition; for its right estimation the demand/supply ratio of the populations must be considered (Pianka 1972); this again implies the knowledge of the physiological background. It is imaginable that in green plants the overlap of niche occurs in certain dimensions without the competitive exclusion taking place. Significant overlaps may come into existence at even identical vegetation levels (for example, on the light axis; cf. Kallis—Tooming 1975). We must agree with Whittaker (1965) that partial competition may be a general phenomenon in the plant community; in such cases, although the species are in competition for basic physiological factors, nevertheless — as a result of fine requirement-shifts in them under the effect of other factors — their coexistence is possible. It seems an important circumstance that the "acquisition" of the indispensable limiting materials and energy in plants takes place from more sources and with the aid of various mechanisms (see light, CO_2, water, nutrient) than in the case of heterotrophs. Coexistence is an important and determining phenomenon in the plant community, which is determined by the partitioning of resources, as, for example, the very important partitioning in time, see for example Fekete—Szujkó-Lacza (1973). Here we refer to Harper—Chatsworth's 1963, *Trifolium repens* and *Tr. fragiferum* experiments; Janzen 1967, and Smythe 1970, bring the coexistence of tropical forests in connexion with the fine shifts occuring in the seasonal rhythm, florescence, fruit ripening, etc. These flowering and fruiting patterns — as is apparent from the works, for example, of Frankie—Baker—Opler 1974, and from those of other — imply in many cases an interaction between plant and animal: the minimum overlap of the periods of florescence is created by the competition for the "services" of birds carrying out pollination). — In certain cases, the populations might be limited by nutrient supply, but this limitation cannot become prevalent (and so no competitive exclusion comes into existence) since another factor (for example the grazing activity of an herbivorous animal species) controls the populations (Harper 1969). Despite these considerations meriting caution, information on the niche volumen of populations, on the overlap of populations in pairs, etc., seems to have a perspective. One can attain with various experimental techniques that the fundamental and the realized niche breadths and the overlaps related to various dimensions can be measured by different plant responses. So did, for example, Pickett—Bazzaz (1976) who could demonstrate in annual species that on the arising of the competition the population centres "recede" from one another on the niche axis, as a result of which their coexistence becomes possible.

Hardly any study is known which could convincingly define the niche-hypervolume of the population in the community. Indeed, the elaboration of an adequate alternative strategy making it possible for responsible niche dimensions to be included into the examinations is still pending. By examining the convertibility of the community, Juhász-nagy (1968) presented the method of selecting the relevant factor and its experimental evidence as well. We must agree with McNaughton—Wolf's view (1973), according to which the species carry on the competition not for the regulators but for the resources. Even though, for example, the pH as an ecological factor in a given case seems relevant, one has to took for the factor (the nutrient factor) which, as regards competition — in the last analysis developing the volume of the niches in the community — is in interaction with the pH (for example, the easily absorbable phosphorus). There is no prediction in relation to the question of the number of dimensions necessary for the niches to separate. According to the experiences of Rogers and King (1972), *Agrostis* species related to one another separate well in already two dimenions. Whittaker (1975) believes that in a semi-desert community three dimensions are already enough to segregate the species well. In general, the included – detected niche-dimensions are abiotical environmental factors; sometimes they are biotic; thirdly, as in Whittaker mentioned above, they are of the plant response type (for example, seasonal rhythm). A characteristic synthesis of the various conceptions is represented by the proposition of the botanist Wuenscher (1969); according to him, all points of the niche can be considered as a vector which contains — besides the measurements of the environmental factors — the responses given to these factors measurable in physiological functions.

The most important advancement in recent years have probably taken place in relation to the technical treatment of the niche hypervolume. The first examples are related to zoo-ecology. GREEN (1971) applied a multiple-discriminant analysis for the investigation of niche-separation in bivalve molluscs; SHUGART—PATTEN (1972) investigated the habitat preference of *Fringillidae* by means of D^2-analysis.

For the niche-characterization of undergrowth plants, FEKETE (1974) applied measurements which were carried out in 6 dimensions; he examined the correlation matrices of the physical factors by means of factor analysis. The configuration of the factor-scores in the factor space takes a characteristic form per species, while in the case of a similar configuration, a time axis — on which each of the values of the relative growth rate of two populations are indicated — may play a separating role.

The niche conception is relevant also to the autotrophous level to the species diversity of the community, and not only to the heterotrophous level (MACARTHUR 1957, MACARTHUR—LEVINS 1967, etc.). The species diversity of animal communities, composed of stable populations consisting of taxonomically related species for example that of nesting birds of forests—supports the random non-overlapping niche hypothesis (broken stick model) proposed by MACARTHUR. It was WHITTAKER's (1965) important article to point out, as the first, that, as a result of the general phenomenon of dominance, the niche space partitioning in the plant community takes probably a different pattern than those which are followed in certain animal communities; at least it follows several models (resource partitioning models, PIELOU 1975). The classified abundancies of the species — or other measurements, as for example productivity — take a pattern according to the geometrical series (niche preemption model) in communities which are composed of species small in number, in a more rigorous environment (for example, in initial old field communities; WHITTAKER 1972). In a more optimal environment, in communities rich in species, the species abudandancies can be considered as a lognormal variable, which is an indication of the fact that a certain representation of the populations is formed by a combined effect of many independent factors which influence the species differently and multiplicatively. MACNAUGHTON—WOLF (1970) develop the conception further and point out that in the plant communities the situaton is different as to relative abundances. According to them, the exclusions that have taken place in the zones of overlapping are indicated by the fact that in the categories of low relative abundance we can find more species, while in the categories of high relative abundace fewer species are to be found, than expected, and that therefore the adjustment of the experienced relative frequencies to the lognormal distribution is not satisfactory. The overlapping niche-hypothesis of MACARTHUR (1957) — in which the niche measurements of the populations is proportional to the distance between 2 random points on the line — was checked by PIELOU (1975) on species which show zonation phenomena along the environmental gradien. She pointed out that the zone breadths of the plant populations examined are considerably more even than indicated by the model. The authors referred to above, and others, called in any case attention to the interrelations between species-diversity and resource-diversity and especially by the analysis of the equitability component (LLOYD—GHELARDI 1964). Since the theory created the technical possibility of controlling, for example, a hypothesis according to which each of the species in a community is mutually exclusive (e.g. each of the populations uses its environment so that it will be unaccessible to the other species), concrete examinations have also been launched, concerning e.g. nutrient limitations (carnivorous versus herbivorous insects; cf. PULLIAM—ODUM—BARRETT 1968). As a result of this, the theory found its way of application also in plant community analyses. ARES (1972), ARES—LEON (1972) for example drew conclusions from the values of biomass-diversity-equitability on the extent of niche separation during succession, by setting the limiting resources at different levels. Here also, the applied model presupposes that limitation takes effect in one dimension only.

The niche conception in plant ecology receives acceptance — sporadically — in the terrain of tolerance ecology and community structure (community diversity). Owing to the causes mentioned above, not very much could be done with it in relation to population dynamics. On the other hand, important dynamical-ecological problems, such as the question of succession, cannot do without the niche conception simply because the fate of the populations is decided in the niche intersections. Even rough approximations (cf. MACNAUGHTON—WOLF 1970) suggest that niche parameters in plant communities (for example, breadths) are sensitive to composition and species number. In the field of zoo-ecology, in tropical bird communities rich in species, CAIN (1969) submits the explanation of the narrow niche breadth of the species. PIELOU (1975) leaves the question open in connection with the richness in species of the tropical plant communities, namely, whether it is the decrease in the average niche volumes or the increase in the average niche overlapping which gives the right explanation. We consider it likely that the narrowing down of the niche breadths of the populations

is a tendency which is valid also in succession, since in multi-specific biotically stressed communities the populations are forced — owing to interspecific competition — to function on the restricted physiological scale, that is around the optimum. It seems a justifiable hypothesis that at the end of the succession series the overlap of a species pair, its relative position in the hyperspace, will be different from that is the initial stage of the succession, if they exist in both phases. By means of the niche conception we can approach questions, as for example, why a population falls out at one point of the succession series and why another is able to infiltrate a developing community; or why the infiltration has taken place as a kind of substitution for the one which has fallen out, or because of an expanding hyperspace — for example, the arising of new niche axes.

The more the hypotheses and speculations, the less the objective measurements—these are characteristics of studies discussing ecological niche. Thanks to some few exceptional authors, we have lately been enabled to choose some feaw niche measurements. The aim of this paper is to evaluate, by means of various indices, the results of objective measurements carried out in the chosen plant community with regard to the niche volumen of the population, the niche overlaps, the distance (separation) of the niche centres, etc., and also by making comparisons between results related to identical parameters obtained by different methods. Accordingly, this first part of the series of our papers is rather methodological in nature; a more objective centred assessment of the niche relations of the species in the community will be made in subsequent parts of the paper series.

Material and method

The species examined and methods of their measuring

The plant community selected for investigation was the calciphilous perennial dry sandy grassland (*Festucetum vaginatae danubiale*; cf. Soó 1957). A nice, wide-ranging stand of this community was chosen from those along the Tece brook near the village Vácrátót (about 30 km N-NE from Budapest), cf. KÁRPÁTI, I.—KÁRPÁTI, V. (1954).

The monthly averages of temperature and the sum of precipitation of the nearest Meteorological Station (Vác, 1976):

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
temperature, °C	0.5	0.6	2.4	11.2	15.4	18.7	21.5	17.7	14.6	11.0	6.3	0.1
precipitation, mm	58	6	17	69	22	29	51	18	124	75	63	119

The semi-closed sandy grassland consists of many species of continental, Pontic, Ponto-Pannonian Hemicryptophytes, Therophytes, and of some Chamaephyte life-form. A list of the flora runs as follows: *Achillea ochroleuca, Alkanna tinctoria, Alyssum gmelini, Andropogon ischaemum, Arenaria serpyllifolia, Bromus tectorum, Carex liparicarpos, C. praecox, C. stenophylla, C. supina, Centaurea arenaria, Cerastium semidecandrum, Corispermum nitidum, Cynodon dactylon, Equisetum ramosissimum, Erophila verna, Euphorbia seguieriana, Festuca vaginata, F. wagneri, Fumana procumbens, Galium verum, Holosteum umbellatum, Kochia laniflora, Koeleria glauca, Linaria genistifolia, Medicago minima, Minuartia verna, Onosma arenaria, Plantago indica, Poa bulbosa, Polygonum arenarium, Salsola kali, Secale silvestre, Silene otites, Stipa joannis, Syrenia cana, Thymus sp., Tragus racemosus, Veronica verna, Cladonia foliacea, Cl. furcata, Cornicularia tenuissima, Syntrychia ruralis.*

On 8 June 1976, two characteristics have been measured with regard to the most frequent 10 species (*Festuca vaginata, Medicago minima, Thymus sp., Fumana procumbens, Euphorbia seguieriana, Carex stenophylla, Minuartia verna, Cynodon dactylon, Equisetum ramosissimum, Centaurea arenaria*) of mass occurrence in the community.

The most important environmental factor in the given conditions was undoubtedly water. Accordingly, we measured the moisture content of the soil with the aid of a portable instrument operating on the basis of electrolyte conductivity. The electrodes were stuck into the soil in contact with the rhyzosphere of the species examined; the values of conductivity directly read from instrument, in mS. After a preliminary calibration of the instrument (on a series of sand samples with known water content), the relationship between the moisture content of the sand soil and its conductivity — in the 0—10% range of the relative moisture content — appeared to be linear; in order to avoid errors that may arise during recalculation, we continued working with the mS values even in the later phases of work. It should be noted that the actual water content was at only a 3—4% maximum even after rainy days.

The other characteristic could be measured on the plant itself: the depth at which the maximum root mass (that of the absorbing roots) of the individuals examined developed. This characteristic is thus in connection with the use and partitioning of space.

The number of measurements was not identical in relation to the various species; the number of the individuals examined approximately reflects the relative frequency of the species in the stand.

For the calculations the data — in relation to both the moisture content of the soil and to the depth of the maximum root mass (for the sake of simplicity hereinafter: root depth) — were later included in groups of five, as follows:

Table 1

Categories set up on the two coordinates

Niche-axis \ Category	1	2	3	4	5
Moisture content of the soil (mS)	.1—.29	.3—.49	.5—.69	.7—.89	.9—
Root depth (cm)	2—3.9	4—5.9	6—7.9	8—9.9	10—

It may seem arbitrary that, as in usual in such cases (cf. COLWELL—FUTUYMA 1971) 5 grades have been set up for each of the factors, but the number of the measurement data and their distribution suggest the formation of nearly that many categories.

The niche measurements applied

In surveying the various measurements used for the estimation of niche breadths and overlap, the following scheme may prove useful:

Species \ Categories	1 . . . j k . . c	Sum total
1	.	
.	.	
.	.	
h	. . . . f_{hj}	$f_{h.}$
i	. . . . f_{ij}	$f_{i.}$
.	.	
.	.	
r	.	
Sum	$f_{.j}$	$f_{..}$

By dividing the values obtained on the niche axis into categories, we can determine the frequency of the species in the various categories, this is the basis of the calculation of the various measurements.

The measurements applied for the estimation of niche breadth

(a) *Measurements related to information theory*

These measurements originate from SHANNON's function-measuring diversity (or they themselves are the SHANNON-function). On the question of measuring diversity, PEET (1974), NOSEK (1976) and others submitted a survey. According to the SHANNON function $H = -\sum_{j=1}^{c} p_{ij} \lg p_{ij}$; the probability of the species occurring in the various categories should be estimated as $p_{ij} = f_{ij}/f_i$. In place of this diversity function, evenness is applied: $H/\lg c$, i.e. the diversity value is divided by the logarithm of the number of categories. In our paper this is indicated as H_i.

For a better estimation of the niche breadth and of the overlap, COLWELL and FUTUYMA (1971) suggested that the various categories of resource states, and the species composition of the communities utilizing them (that is, the distribution according to categories of the occurring species — the heterogeneity of the matrix) be used for the calculation of weighting factors (d_j). These weight values express the degree of distinctness of the categories. The original matrix can at a later phase be extended to a greater category number, if it is chosen appropriately. In our case, we chose this k to be 100. By multiplying it with a standardizing factor $\frac{k}{\lg k}$, the niche breadths denoted below $C_{i;w}$ is calculated by the weighting factors on the basis of SHANNON's function from the transformed probability values, as

$$C_{i;w} = -\frac{k}{\lg k} \sum_{j} d_j p^*_{ij} \lg p^*_{ij} .$$

PIELOU (1967) justifiably criticizes the use of SHANNON function; she suggests BRILLOUIN's function instead. PIELOU (1972) estimates the niche breadth from the decomposed value of $H_T = \frac{1}{f..} \lg \frac{f..!}{\Pi f_{ij}!}$, which is calculated from the $r \times c$ table. The value of H_T can be divided into pairs of components in two ways:

(i) by breaking it down into the average niche breadths ($h_i(b)$) of the species or into the weighted average niche breadths ($u_i h_i(b)$) and the species diversity of the entire collection;

(ii) or by giving the species diversity in categories; PIELOU (1972) considers the categories as niche overlap, while the diversity as categories.

(*b*) LEVINS (1968) worked out an index for the estimation of niche breadth:

$$B_i = \frac{1}{\sum p_{ij}^2}$$

Measurements applied for the estimation of niche overlap

(a) *Measurements related to the information theory*

HORN (1966) suggests in his study (after mentioning MORISITA's index) the following formula:

$$R_0 = R_{hi} = \frac{H_{obs.} - H_{min.}}{H_{max.} - H_{min.}}$$

where $H_{obs.}$ = observed, $H_{min.}$ = minimum, $H_{max.}$ = maximum entropy.

In our opinion, this equation can be used for the estimation of the overlap of even more than two species.

In the foregoing, we have already mentioned PIELOU's method (1972) in which she considered the diversity of the categories as a measure of the overlap.

(*b*) An overlap index related to the examination of competition has been worked out by LEVINS (1968). For the approximation of the values of α and β (competition coefficients) occurring in the known LOTKA—VOLTERRA equations, he suggested the following formula:

$$\alpha = \alpha_{hi} = \sum p_{hj}p_{ij}/\sum p_{hj}^2 \quad \text{and} \quad \beta = \alpha_{ih} = \sum p_{hj}p_{ij}/\sum p_{ij}^2$$

where α_{hi} refers to the effect of species i on species h, while α_{ih} estimates the effect of species h on species i.
The values of the two α are identical when the niche breadth of the two species is identical.
(*c*) Similarity (ecological similarity) indices were used by SCHOENER (1970) who applied the $C_{hi} = 1 - 1/2 \sum | p_{hj} - p_{ij} |$ index worked out by WWITTAKER—FAIRBANKS (1958).
(d) For the estimation of the overlap, LEVINS (1968) suggests the determination of the geometric distance. In our study, we calculated the Euclidean distance between the species, on the basis of normalized vectors (ORLÓCI, 1967). The distance named by him as chord distance will hereinafter be denoted by d; its maximum value is 1.41, its minimum is 0. The greater the d between two species, the smaller the overlap may be and vice versa.
(e) For measuring the distance between the niche centres of the species, SHUGART and PATTEN (1972) applied the D^2 statistics. Our paper gives the value of D related to some species pairs.

By means of niche breadth and overlap, measurements enumerated above as

$$H_i,\ h_i(b),\ u_ih_i(b),\ C_{i;w},\ B_i - R_{hi},\ \alpha_{hi} \text{ and } \alpha_{ih},\ C_{hi},$$

and by means of the d-value, we performed two kinds of calculation:

(i) with the original data, when no symbol w occurs with the measurements;

(ii) with the values re-calculated by means of the weights given by COLWELL—FUTUYMA, which is indicated by the symbol w accompanying the measurement. — An exception is PIELOU's function, where the weighting was made in the way given by her, and where also her designation was taken over.

The parameter values of breadth and overlap are estimated by the enumerated measurement, both separately as to dimension and in combinations, according to the combined categories of the two dimensions.

Results and discussion

Niche breadth

The distribution of the species (basic data) according to the categories of soil moisture contents and their niche breadths per these dimensions — calculating by the measurements mentioned above — is shown in Tables 2—5 and 19—20. The measurements are of different origins — as has been indicated — therefore no identical values could be expected. The weighting mentioned (cf. the methods of COLWELL and FUTUYMA, and PIELOU) has obviously changed the values even in the case of calculating the measurements by the identical method. It appears in Table 6, however, where the arrangement of the species is given according to the various measurements, that *Festuca* has the greatest niche breadths, whichever of the measurements is used. The narrowest niche breadth belongs to *Equisetum;* with the exception of two cases, viz. $u_ih_i(b)$ and $B_{i;w}$, it is the last one in the order of sequence.

On the basis of the preceding Table (6), we calculated the rank correlation between measurements (see Table 7). H_i — with the exception of indices $H_{i,w}$ and $B_{i,w}$ — showed a significant positive correlation with all

Table 2

Distribution of species frequency in the categories of soil moisture content

mS Species	0.10—0.29	0.30—0.49	0.50—0.69	0.70—0.89	0.90—	Sum
Festuca	6	6	4	3	1	20
Medicago	1	3	6	2	0	12
Thymus	3	4	4	0	1	12
Fumana	0	1	2	2	6	11
Euphorbia	1	1	1	3	5	11
Carex	4	4	2	1	0	11
Minuartia	1	4	3	0	0	8
Cynodon	2	1	2	0	0	5
Equisetum	2	2	0	0	0	4
Centaurea	1	0	1	1	0	3
Sum	21	26	25	12	13	97

Table 3

Species niche breadths and overlap
Soil moisture content

	Festuca	*Medicago*	*Thymus*	*Fumana*	*Euphorbia*	*Carex*	*Minuartia*	*Cynodon*	*Equisetum*	*Centaurea*
Festuca	*0.918* *0.962*	0.883	0.916	0.641	0.749	0.968	0.858	0.893	0.832	0.856
Medicago	0.839	*0.744* *0.783*	0.827	0.598	0.620	0.860	0.884	0.841	0.586	0.821
Thymus	0.915	0.744	*0.798* *0.859*	0.577	0.625	0.888	0.934	0.940	0.790	0.633
Fumana	0.595	0.363	0.584	*0.727* *0.458*	0.934	0.471	0.453	0.418	0.219	0.525
Euphorbia	0.698	0.429	0.637	0.956	*0.847* *0.599*	0.601	0.474	0.524	0.439	0.690
Carex	0.928	0.850	0.818	0.286	0.414	*0.783* *0.773*	0.882	0.915	0.878	0.797
Minuartia	0.804	0.662	0.859	0.251	0.334	0.863	*0.608* *0.635*	0.898	0.750	0.564
Cynodon	0.862	0.814	0.884	0.238	0.350	0.920	0.892	*0.655* *0.633*	0.757	0.721
Equisetum	0.810	0.587	0.761	0.115	0.305	0.887	0.744	0.802	*0.431* *0.421*	0.399
Centaurea	0.844	0.830	0.590	0.362	0.535	0.815	0.556	0.708	0.456	*0.682* *0.676*

In the main diagonal the upper value is H_i, the lower value is $H_{i;w}$.
In the right semimatrix R_{hi}, in the left semimatrix $R_{hi;w}$

measurement. Index $H_{i,w}$. is in the strongest positive correlation with index $B_{i,w}$. A strong positive correlation can be detected between PIELOU's functions. It is interesting that $C_{i,w}$ is in a reliable correlation with the non-weighted other measurements, except for $u_i h_i(b)$. Index B_i is in a significant correlation with all other measurement implying that LEVIN's formula approximates the other measurements well. Index $B_{i,u}$ which is also LEVINS's formula, though

Table 4

Species niche breadth and overlap on the basis of indices $C_{i;w}$, C_{hi} and $C_{hi;w}$
Soil moisture content

	Festuca	*Medicago*	*Thymus*	*Fumana*	*Euphorbia*	*Carex*	*Minuartia*	*Cynodon*	*Equisetum*	*Centaurea*
Festuca	*0.947*	0.683	0.805	0.472	0.475	0.875	0.625	0.700	0.600	0.655
Medicago	0,644	*0.825*	0.667	0.440	0.435	0.605	0.708	0.683	0.315	0.583
Thymus	0.791	0.592	*0.914*	0.355	0.360	0.770	0.790	0.785	0.583	0.590
Fumana	0.347	0.213	0.335	*0.914*	0.815	0.363	0.265	0.272	0.090	0.365
Euphorbia	0.424	0.299	0.359	0.879	*0.947*	0.370	0.273	0.275	0.185	0.455
Carex	0.813	0.593	0.678	0.213	0.239	*0.842*	0.670	0.745	0.725	0.610
Minuartia	0.554	0.695	0.676	0.114	0.138	0.630	*0.771*	0.700	0.625	0.458
Cynodon	0.653	0.621	0.696	0.113	0.138	0.762	0.682	*0.793*	0.600	0.665
Equisetum	0.559	0.338	0.525	0.038	0.098	0.745	0.581	0.658	*0.727*	0.335
Centaurea	0.636	0.579	0.527	0.176	0.259	0.635	0.437	0.646	0.380	*0.821*

In the main diagonal $C_{i;w}$, in the right semi-matrix C_{hi}, in the left semimatrix $C_{hi;w}$

Table 5

Species niche breadths on the basis of Pielou's function

	Root depth		Soil moisture content	
	$h_i(b)$	$u_i h_i(b)$	$h_i(b)$	$u_i h_i(b)$
Festuca	0.363	0.075	0.526	0.108
Medicago	0.346	0.043	0.395	0.049
Thymus	0.370	0.046	0.428	0.053
Fumana	0.202	0.023	0.375	0.043
Euphorbia	0.424	0.048	0.440	0.049
Carex	0.306	0.035	0.412	0.047
Minuartia	0.113	0.009	0.306	0.025
Cynodon	0.295	0.152	0.295	0.015
Equisetum	0.150	0.006	0.194	0.008
Centaurea	0.000	0.000	0.259	0.008

Table 6

Species niche breadths sequence
Soil moisture content

	H_i	H_i; w	$h_i(b)$	$u_i h_i(b)$	C_i; w	B_i	B_i; w
Festuca	1	1	1	1	1.5	1	1
Medicago	5	3	5	3.5	6	6	3
Thymus	3	2	3	2	3.5	2	2
Fumana	6	9	6	6	3.5	8	10
Euphorbia	2	8	2	3.5	1.5	3.5	9
Carex	4	4	4	5	5	3.5	4
Minuartia	9	6	7	7	9	9	6
Cynodon	8	7	8	8	8	7	7
Equisetum	10	10	10	9.5	10	10	8
Centaurea	7	5	9	9.5	7	5	5

Table 7

Rank correlations between the niche breadth measurements
Soil moisture content
(see Table 6)

Index / Index	H_i; w	$h_i(b)$	$u_i h_i(b)$	C_i; w	B_i	B_i; w
H_i	0.612	0.952***	0.891***	0.939***	0.915***	0.467
H_i; w		0.588	0.673*	0.394	0.758*	0.964***
$h_i(b)$			0.952***	0.891***	0.818**	0.442
$u_i h_i(b)$				0.809**	0.791**	0.758
C_i; w					0.785**	0.212
B_i						0.655*

* significant at 5%
** at 1%
*** at 0.1% level

with weighted values, is in correlation only with $H_{i,w}$ and with the non-weighted original formula.

The basic data and the niche breadths related to root depths are given per measurements in Tables 5, 8, 10 and 21—22. Considering the arrangement of the species (Table 11), *Euphorbia* has the greatest niche breadth by almost all the measurements. *Centaurea* has the narrowest niche breadth, as it occurred only in one category. *Minuartia* and *Equisetum* occurred most frequently as 9 and 8 in the order.

Table 8

Distribution of species frequency in the root depth categories

cm / Species	2.0—3.9	4.0—5.9	6.0—7.9	8.0—9.9	10.0—	Sum
Festuca	1	9	9	1	0	20
Medicago	6	4	2	0	0	12
Thymus	4	5	3	0	0	12
Fumana	0	0	0	3	8	11
Euphorbia	0	1	3	4	3	11
Carex	6	4	1	0	0	11
Minuartia	7	1	0	0	0	8
Cynodon	0	2	2	0	1	5
Equisetum	0	3	1	0	0	4
Centaurea	0	0	3	0	0	3
Sum	24	29	24	8	12	97

Table 9

Species niche breadths and overlaps
Root depth

	Festuca	*Medicago*	*Thymus*	*Fumana*	*Euphorbia*	*Carex*	*Minuartia*	*Cynodon*	*Equisetum*	*Centaurea*
Festuca	*0.682* *0.633*	0.690	0.983	0.090	0.536	0.642	0.396	0.736	0.905	0.764
Medicago	0.761	*0.518* *0.630*	0.976	0.000	0.264	0.994	0.906	0.474	0.596	0.367
Thymus	0.868	0.978	*0.637* *0.669*	0.000	0.332	0.956	0.807	0.586	0.732	0.494
Fumana	0.111	0.000	0.000	*0.277* *0.439*	0.790	0.000	0.000	0.456	0.000	0.000
Euphorbia	0.622	0.371	0.434	0.739	*0.764* *0.802*	0.219	0.048	0.793	0.459	0.521
Carex	0.702	0.991	0.952	0.000	0.315	*0.463* *0.567*	0.928	0.420	0.558	0.247
Minuartia	0.374	0.852	0.736	0.000	0.111	0.887	*0.144* *0.323*	0.133	0.186	0.000
Cynodon	0.834	0.640	0.733	0.349	0.762	0.637	0.220	*0.682* *0.655*	0.785	0.600
Equisetum	0.925	0.743	0.838	0.000	0.605	0.822	0.294	0.853	*0.365* *0.349*	0.499
Centaurea	0.758	0.448	0.554	0.000	0.578	0.309	0.000	0.636	0.470	*0.000* *0.000*

In the main diagonal the upper value is $H_{i,w}$, the value below is H_i. In the right semimatrix $R_{hi,w}$, in the left semimatrix R_{hi}

Table 10

Species niche breadths and overlaps on the basis of $C_{i;w}$, C_{hi} and $C_{hi;w}$
Root depths

	Festuca	*Medicago*	*Thymus*	*Fumana*	*Euphorbia*	*Carex*	*Minuartia*	*Cynodon*	*Equisetum*	*Centaurea*
Festuca	*0.834*	0.550	0.717	0.050	0.413	0.505	0.175	0.800	0.700	0.450
Medicago	0.418	*0.858*	0.833	0.000	0.257	0.924	0.625	0.500	0.500	0.167
Thymus	0.585	0.833	*0.684*	0.000	0.340	0.788	0.458	0.650	0.667	0.250
Fumana	0.047	0.000	0.000	*0.788*	0.545	0.000	0.000	0.200	0.000	0.000
Euphorbia	0.389	0.182	0.265	0.580	*0.914*	0.181	0.090	0.563	0.340	0.272
Carex	0.376	0.886	0.791	0.000	0.127	*0.842*	0.670	0.455	0.455	0.091
Minuartia	0.157	0.739	0.573	0.000	0.059	0.782	*0.766*	0.125	0.125	0.000
Cynodon	0.672	0.321	0.488	0.327	0.622	0.278	0.064	*0.858*	0.650	0.400
Equisetum	0.675	0.321	0.487	0.000	0.294	0.278	0.060	0.590	*0.753*	0.250
Centaurea	0.458	0.178	0.199	0.000	0.228	0.062	0.000	0.360	0.278	*0.586*

In the main diagonal $C_{i;w}$, in the right semimatrix C_{hi}, in the left semimatrix $C_{hi;w}$

Table 11

Species niche breadths sequence
Root depth

Index / Species	H_i	H_i; w	$h_i(b)$	$u_i h_i(b)$	C_i; w	B_i	B_i; w
Festuca	4	2	3	2	5	5	3
Medicago	5	5	4	5	2.5	4	5
Thymus	2	4	2	4	9	2	4
Fumana	7	8	7	7	6	7	8
Euphorbia	1	1	1	3	1	1	1
Carex	6	6	5	6	4	6	6
Minuartia	9	9	9	8	7	9	9
Cynodon	3	3	6	1	2.5	3	2
Equisetum	8	7	8	9	8	8	7
Centaurea	10	10	10	10	10	10	10

The rank correlation coefficients calculated between the measurements (Table 12) now show a different picture from that in Table 7 (soil moisture content). Index B_i is in a positive correlation of some strength with each of the others also now, and even $B_{i,w}$ shows the same connection. We cannot draw an unambiguous conclusion from the two Tables (7 and 12).

Table 12

Rank correlations between the niche breadth measurements
Root depth
(see also Table 11)

Index / Index	H_i; w	$h_i(b)$	$u_i h_i(b)$	C_i; w	B_i	B_i; w
H_i	0.939***	0.927***	0.891***	0.600	0.988***	0.952***
H_i; w		0.891***	0.915***	0.673*	0.903***	0.988***
$h_i(b)$			0.769**	0.552	0.915***	0.855**
$u_i h_i(b)$				0.673*	0.855**	0.927***
C_i; w					0.630*	0.703**
B_i						0.927***

For remarks see Table 7

Niche overlap

The overlaps calculated by means of the various measurements (C_{hi}, $C_{hi,w}$, R_{hi} and $R_{hi,w}$) occuring between the species are to be found in Tables 3, 4, 9 and 10. In Tables 13 and 14, also the Euclidean distances (d) calculated between the pairs of species are given.

Table 13

The Euclidean distance (d) between the species
Soil moisture content

	Festuca	*Medicago*	*Thymus*	*Fumana*	*Euphorbia*	*Carex*	*Minuartia*	*Cynodon*	*Equisetum*	*Centaurea*
Festuca		0.662	0.398	0.884	1.001	0.199	0.854	0.493	0.534	0.489
Medicago	0.758		0.527	1.090	1.116	0.766	0.508	0.617	1.089	0.715
Thymus	0.420	0.731		1.069	1.089	0.415	0.348	0.380	0.685	0.912
Fumana	1.121	1.313	1.003		0.296	1.228	1.189	1.225	1.337	1.144
Euphorbia	1.050	1.296	1.030	0.136		1.208	1.218	1.203	1.239	1.019
Carex	0.334	0.821	0.570	1.362	1.304		0.567	0.481	0.373	0.816
Minuartia	0.715	0.553	0.586	1.350	1.348	0.660		0.648	0.781	1.044
Cynodon	0.520	0.742	0.531	1.368	1.333	0.413	0.701		0.764	0.677
Equisetum	0.553	1.102	0.728	1.396	1.341	0.324	0.839	0.614		1.087
Centaurea	0.654	0.751	0.914	1.326	1.248	0.739	1.065	0.716	0.893	

In the right semi-matrix the values calculated from the non-weighted data, in the left semi-matrix the values calculated from the weighted data

Table 14

The Euclidean distance (d) between the species
Root depth

	Festuca	*Medicago*	*Thymus*	*Fumana*	*Euphorbia*	*Carex*	*Minuartia*	*Cynodon*	*Equisetum*	*Centaurea*
Festuca		0.864	0.567	1.395	0.972	0.952	1.283	0.355	0.471	0.771
Medicago	1.054		0.332	1.414	1.244	0.133	0.511	0.965	0.904	1.211
Thymus	0.812	0.282		1.414	1.153	0.417	0.825	0.701	0.624	1.073
Fumana	1.403	1.414	1.414		0.759	1.414	1.414	1.173	1.414	1.414
Euphorbia	1.079	1.343	1.277	0.582		1.294	1.397	0.872	1.166	0.993
Carex	1.099	0.079	0.328	1.414	1.366		0.461	1.041	0.933	1.313
Minuartia	1.267	0.271	0.547	1.414	1.409	0.243		1.346	1.316	1.414
Cynodon	0.600	1.221	1.037	0.956	0.739	1.254	1.388		0.560	0.816
Equisetum	0.520	1.169	0.943	1.414	1.225	1.182	1.369	0.723		1.169
Centaurea	0.711	1.295	1.164	1.414	1.091	1.353	1.414	0.869	1.136	

In the right semi-matrix the values calculated from non-weighted data, in the left semi-matrix the values calculated form the weighted data

The average overlaps for the various species (the average of the overlaps occurring between the given species and all the other species) were also determined. Tables 15 and 16 contain the order of these averages. The values d were similarly treated (Tables 15 and 16).

Table 15

Species average niche overlap order
Soil moisture content

Measurement / Species	C_{hi}	C_{hi}; w	R_{hi}	R_{hi}; w	d^*	d^*; w
Festuca	1	1	1	1	1	1
Medicago	5	5	4	5	5	7
Thymus	3	3	3	2	2	2
Fumana	10	10	10	10	10	10
Euphorbia	9	9	8	9	9	9
Carex	2	2	2	3	3	3
Minuartia	7	6	6	6	6	6
Cynodon	4	4	5	4	4	4
Equisetum	8	8	9	8	8	5
Centaurea	6	7	7	7	7	8

* Starting from the smallest distance

Table 16

Species average niche overlap sequence
Root depth

Measurement / Species	C_{hi}	C_{hi}; w	R_{hi}	R_{hi}; w	d^*	d^*; w
Festuca	2	3	2	2	3	4
Medicago	3	2	3	3	2	2
Thymus	1	1	1	1	1	1
Fumana	10	10	10	10	10	10
Euphorbia	7	7	7	7	7	8
Carex	5	5	5	5	5	3
Minuartia	8	8	9	9	8	6
Cynodon	4	4	4	4	4	5
Equisetum	6	6	6	6	6	7
Centaurea	9	9	8	8	9	9

* Starting from the smallest distance

On the basis of the average overlaps — with regard to soil moisture content — *Festuca* stands at the first place by all the measurements, which means that it has great overlaps with most of the species. On the other hand, the average overlap of *Euphorbia* and *Fumana* is the smallest. The reversed order of sequence classification of the *d*-values supports what has been said in the foregoing.

Table 17

Distribution of the niche overlap and d-values
Soil moisture content

Class* / Measurement	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0
C_{hi}							3	8	12	3	6	7	4	1	1
C_{hi}; w							2	3	13	8	2	5	5	5	2
R_{hi}						6	14	6	6	6	5	1	1		
R_{hi}; w						4	16	4	3	6	3	5	3	1	
d		1	6	3	8	1	3	4	5	4	4	4	1	1	
d; w		10	2	2	4	1	3	9	3	6	2	2	0	1	

* The starting values of the classes are indicated; 0.0 represents interval 0.00—0.09 etc.

Table 18

Distribution of the niche overlap and d-values
Rooth depth

Measurement \ Class*	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0
C_{hi}						1	2	3	5	6	6	2	4	5	11
C_{hi}; w							2	3	3	4	4	6	6	5	12
R_{hi}						4	7	8	5	2	3	5	2	2	7
R_{hi}; w						7	1	6	3	5	6	3	3	2	9
d	7	5	4	4	2	6	4	3	1	3	3	2	0	1	0
d; w	9	5	6	4	5	2	2	3	1	3	0	1	3	0	1

* See Table 17

By examining the order of rank of the measurements in the case of maximum root depths (Table 16), *Thymus* takes the first place and *Fumana* again the last one.

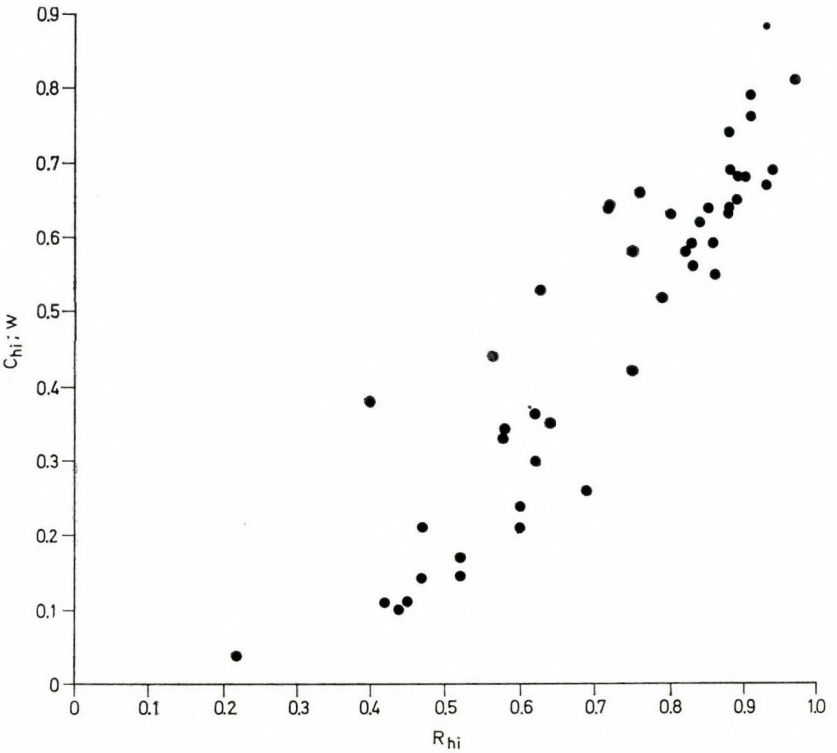


Fig. 1. Relationship between R_{hi} and $C_{hi;w}$. Soil moisture content

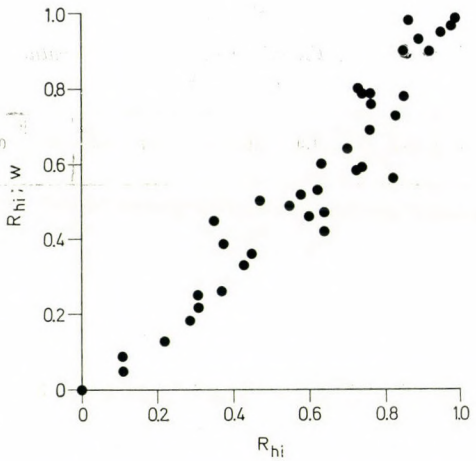


Fig. 2. Relationship between R_{hi} and $R_{hi;w}$. Root depth

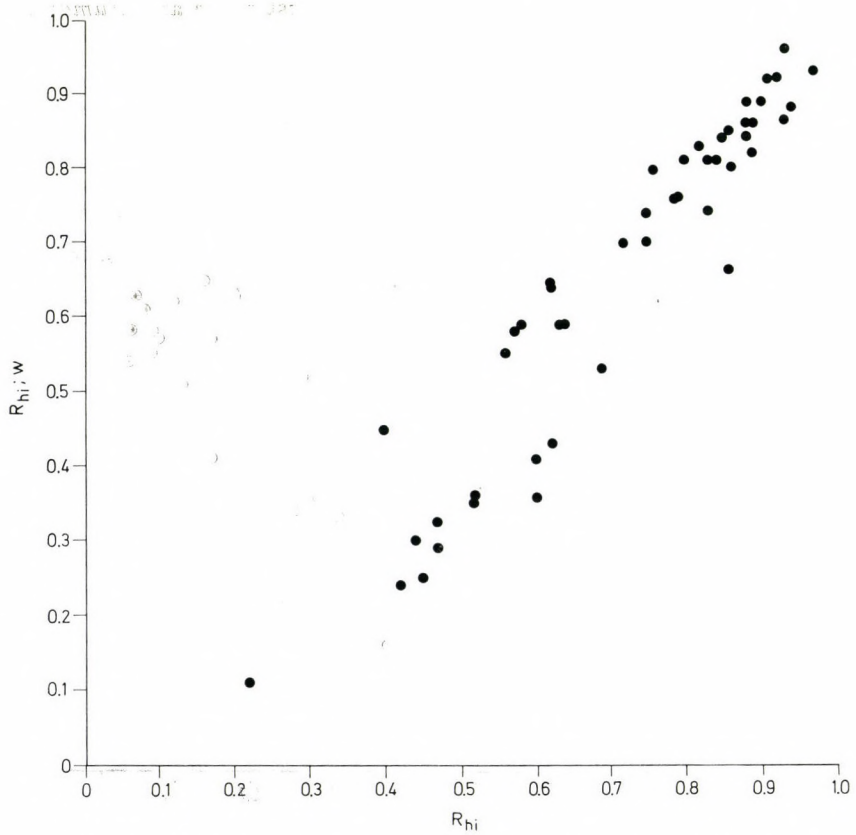


Fig. 3. Relationship between R_{hi} and $R_{hi;w}$. Soil moisture content

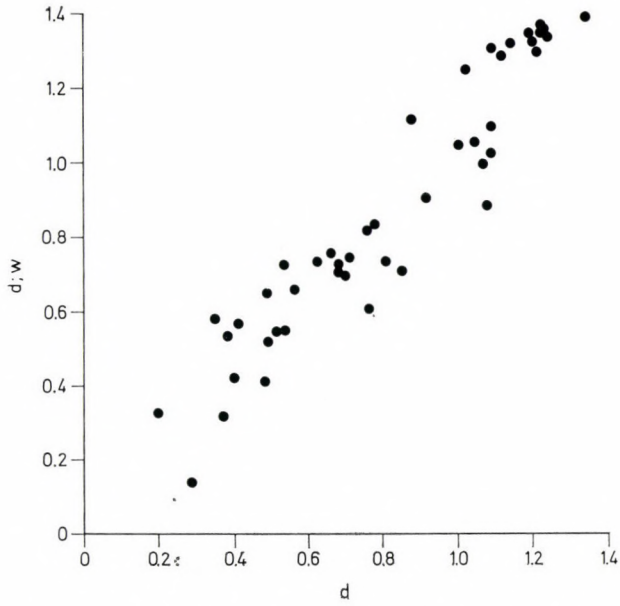


Fig. 4. Relationship between values d and d_w. Soil moisture content

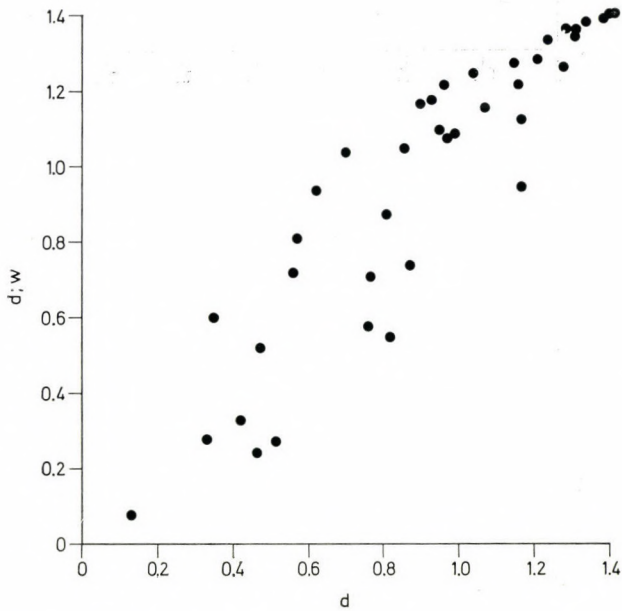


Fig. 5. Relationship between values d and d_w. Root depth

All the rank correlation coefficients between the various measurements and the d and d_w values are above 0.9.

Among the C_{hi} indices the most frequent is the 0.6 value overlap, while among the R_{hi} functions the 0.8 overlap; in d's the most frequent values are and 1.3, in the case of soil moisture content (Table 17).

In the case of root depths, the 0 overlap value is the most frequent in C_{hi} indices. Among the R_{hi}'s, in non-weighted cases, the overlap values are the most frequent in the 0.7—0.8 and 0 categories, while in weighted cases in the 0.7 and 0 categories. The d values show a maximum in the 1.4 category, which corresponds to the 0 overlap (Table 18).

In the case of soil moisture content, an approximately linear correlation exists between R_{hi} and $C_{hi,w}$ (Fig. 1). Similarly, there is a linear correlation

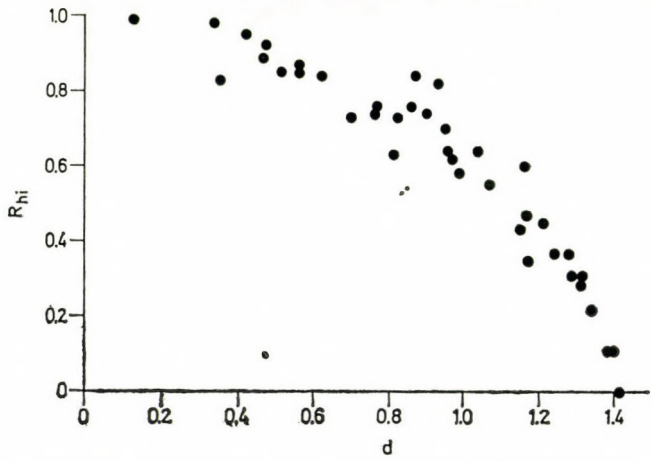


Fig. 6. Relationship between R_{hi} and d. Root depth

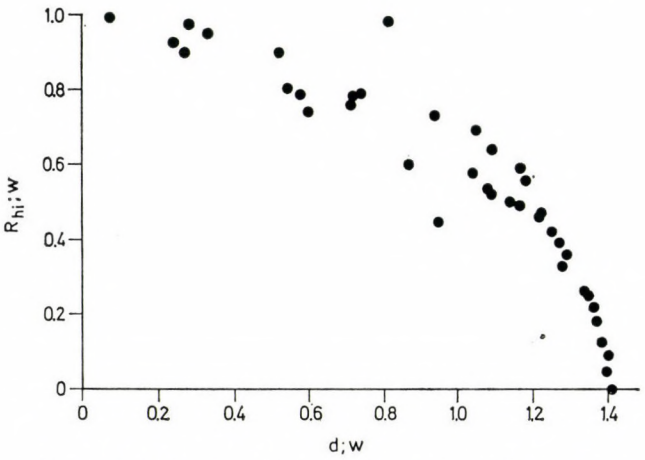


Fig. 7. Relationship between $R_{hi;w}$ and d_w. Root depth

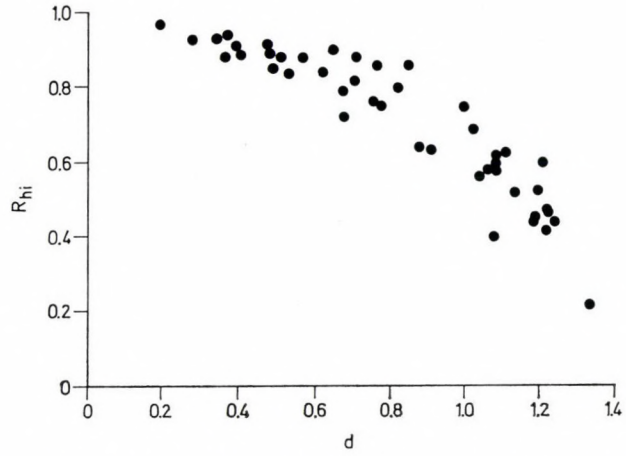


Fig. 8. Relationship between R_{hi} and d. Soil moisture content

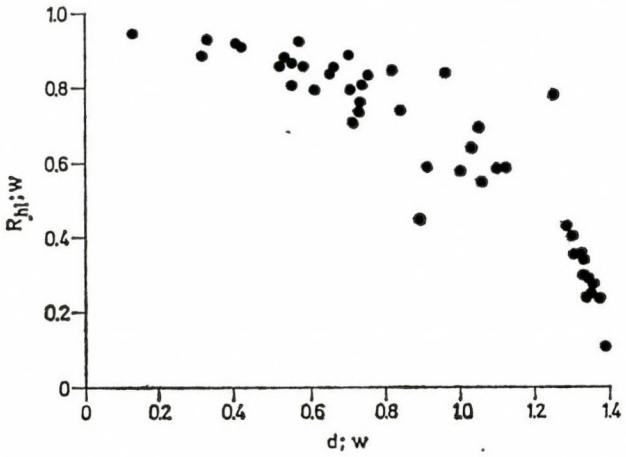


Fig. 9. Relationship between $R_{hi;w}$ and d_w. Soil moisture content

between R_{hi} and $R_{hi,w}$, and also between the d—d_w values (Figs 2—5). By examining any one of the factors, a curvilinear relationship is obtained between R_{hi} and d (Figs 6—9) and this is valid also when the categories of soil moisture content and root depth are calculated in combination. No explanation could be found in respect of this relationship.

On the basis of the α_{12} and α_{21} values (Tables 19, 20, 21 and 22), which represent the community matrices, the species effect and the community effect were calculated (Tables 23 and 24; cf. VANDERMEER 1972).

In the case of soil moisture content, the species effect calculated by using the unweighted and the weighted data showed a very different ordering of

the species. There is no good agreement in the sequence of the species with regard to community effect either, if we compare the weighted and the non-weighted indices. What can be inferred is that *Fumana* and *Euphorbia* have

Table 19

Community matrix
Soil moisture content
(on the basis of non-weighted values)

	Festuca	*Medicago*	*Thymus*	*Fumana*	*Euphorbia*	*Carex*	*Minuartia*	*Cynodon*	*Equisetum*	*Centaurea*
Festuca	*4.081*	0.918	1.003	0.482	0.557	1.095	1.071	1.061	1.224	0.884
Medicago	0.648	*2.880*	0.780	0.414	0.349	0.654	0.930	0.816	0.480	0.720
Thymus	0.843	0.929	*3.429*	0.467	0.416	0.935	1.107	1.028	1.000	0.667
Fumana	0.318	0.387	0.366	*2.689*	0.866	0.222	0.305	0.244	0.122	0.326
Euphorbia	0.446	0.396	0.396	1.054	*3.271*	0.351	0.297	0.297	0.297	0.495
Carex	0.877	0.743	0.892	0.270	0.351	*3.271*	0.966	0.952	1.189	0.694
Minuartia	0.646	0.795	0.795	0.280	0.224	0.727	*2.461*	0.738	0.769	0.410
Cynodon	0.722	0.787	0.833	0.252	0.252	0.808	0.833	*2.778*	0.833	0.741
Equisetum	0.600	0.333	0.583	0.091	0.182	0.727	0.625	0.600	*2.000*	0.333
Centaurea	0.650	0.750	0.583	0.364	0.454	0.636	0.500	0.800	0.500	*3.000*

In the main diagonal B_i, in the upper semi-matrix α_{12}, in the lower semi-matrix value α_{21}

Table 20

Community matrix
Soil moisture content
(on the basis of weighted values)

	Festuca	*Medicago*	*Thymus*	*Fumana*	*Euphorbia*	*Carex*	*Minuartia*	*Cynodon*	*Equisetum*	*Centaurea*
Festuca	*4.4189*	0.8418	0.9512	1.5725	0.6792	1.1257	0.9576	1.1158	1.2815	0.9629
Medicago	1.6609	*3.1605*	0.6536	0.1940	0.2092	0.6596	0.9207	0.7920	0.4993	0.7405
Thymus	0.8567	1.2147	*3.9809*	0.7727	0.7309	0.9367	1.0123	1.0469	1.0430	0.6668
Fumana	0.5592	0.0965	0.3051	*1.5711*	0.9013	0.0517	0.0692	0.0487	0.0251	0.0868
Euphorbia	0.2932	0.1263	0.3502	1.0939	*1.9076*	0.1160	0.0816	0.0946	0.0992	0.1751
Carex	0.7962	0.6524	0.7355	0.1616	0.1901	*3.1259*	0.8443	0.9941	1.2129	0.7465
Minuartia	1.7554	0.7658	0.6685	0.1819	0.1125	0.7100	*2.6288*	0.7461	0.7466	0.4017
Cynodon	1.5196	0.6531	0.6854	0.0808	0.1293	0.8288	0.7396	*2.6062*	0.9382	0.6932
Equisetum	0.5622	0.3063	0.5079	0.0310	0.1008	0.7522	0.5506	0.6979	*1.9387*	0.4304
Centaurea	0.6403	0.6885	0.4922	0.1622	0.2698	0.7017	0.4490	0.7817	0.6524	*2.9386*

In the main diagonal values $B_{i,w}$; see also Table 19

Table 21

Community matrix
Root depth
(on the basis of non-weighted values)

	Festuca	*Medicago*	*Thymus*	*Fumana*	*Euphorbia*	*Carex*	*Minuartia*	*Cynodon*	*Equisetum*	*Centaurea*
Festuca	*2.4390*	0.6098	0.7724	0.0332	0.4434	0.5654	0.2439	0.8780	1.0976	1.0976
Medicago	0.6428	*2.5713*	0.8928	0.0000	0.1949	1.0519	1.2322	0.5143	0.7501	0.4286
Thymus	0.9122	1.0000	*2.8802*	0.0000	0.2837	1.0256	0.9899	0.7681	1.0801	0.7200
Fumana	0.0225	0.0000	0.0000	*1.6575*	0.4931	0.0000	0.0000	0.2412	0.0000	0.0000
Euphorbia	0.6286	0.2621	0.3406	1.0287	*3.4575*	0.1999	0.0394	0.6916	0.4716	0.9429
Carex	0.5292	0.9340	0.8130	0.0000	0.1320	*2.2831*	1.1936	0.4151	0.6744	0.2075
Minuartia	0.1280	0.6133	0.4399	0.0000	0.0146	0.6691	*1.2799*	0.0640	0.1201	0.0000
Cynodon	1.0000	0.5556	0.7408	0.4042	0.5556	0.5050	0.1389	*2.7778*	1.1111	1.1111
Equisetum	0.7200	0.4667	0.6000	0.0000	0.2182	0.4726	0.1501	0.6400	*1.6000*	0.6944
Centaurea	0.4500	0.1667	0.2500	0.0000	0.2727	0.0909	0.0000	0.4000	0.2500	*1.0000*

In the main diagonal values B_i; see Table 19

Table 22

Community matrix
Root depth
(on the basis of weighted data)

	Festuca	*Medicago*	*Thymus*	*Fumana*	*Euphorbia*	*Carex*	*Minuartia*	*Cynodon*	*Equisetum*	*Centaurea*
Festuca	*2.638*	0.521	0.674	0.021	0.380	0.484	0.299	0.770	1.089	1.213
Medicago	0.380	*1.922*	0.824	0.000	0.087	1.041	1.255	0.204	0.341	0.225
Thymus	0.667	1.118	*2.609*	0.000	0.167	1.151	1.290	0.431	0.696	0.522
Fumana	0.011	0.000	0.000	*1.378*	0.547	0.000	0.000	0.369	0.000	0.000
Euphorbia	0.458	0.143	0.203	1.260	*3.175*	0.090	0.014	0.749	0.345	0.721
Carex	0.324	0.955	0.778	0.000	0.050	*1.763*	1.211	0.164	0.310	0.113
Minuartia	0.128	0.739	0.560	0.000	0.004	0.777	*1.132*	0.022	0.051	0.000
Cynodon	0.873	0.317	0.494	0.800	0.705	0.227	0.059	*2.990*	0.990	1.076
Equisetum	0.687	0.295	0.444	0.000	0.181	0.292	0.075	0.550	*1.663*	0.457
Centaurea	0.460	0.117	0.200	0.000	0.227	0.064	0.000	0.360	0.275	*1.000*

In the main diagonal values $B_{i,w}$; see Table 19

hardly any effect on the distribution of the other species according to soil moisture content, and the other species have no influence on the distribution of the two species (*Fumana* and *Euphorbia*) according to soil moisture content either.

As regards root depth, both the species effect and the community effect show the smallest value in *Fumana*, either by the weighted or by the non-weighted data. The situation is similar also here to that in the case of soil

Table 23

Species effect and community effect
Soil moisture content

	Community effect				Species effect			
	Calculated on the basis of data							
	non-weighted		weighted		non-weighted		weighted	
Festuca	0.639	(7)	1.054	(1)	0.922	(1)	0.960	(1)
Medicago	0.671	(6)	0.703	(4)	0.643	(5)	0.594	(7)
Thymus	0.692	(4)	0.920	(2)	0.821	(2)	0.594	(6)
Fumana	0.408	(9)	0.238	(10)	0.351	(10)	0.472	(9)
Euphorbia	0.406	(10)	0.270	(9)	0.448	(9)	0.369	(10)
Carex	0.684	(5)	0.704	(3)	0.771	(3)	0.654	(4)
Minuartia	0.737	(1)	0.676	(6)	0.598	(6)	0.625	(5)
Cynodon	0.726	(2)	0.696	(5)	0.674	(4)	0.702	(3)
Equisetum	0.713	(3)	0.438	(8)	0.453	(8)	0.722	(2)
Centaurea	0.586	(8)	0.537	(7)	0.582	(7)	0.545	(8)

The rank numbers are in brackets

Table 24

Species effects and community effects
Root depth

	Species effect				Community effect			
	Calculated on the basis of data							
	non-weighted		weighted		non-weighted		weighted	
Festuca	0.559	(3)	0.606	(3)	0.638	(3)	0.443	(7)
Medicago	0.512	(6)	0.484	(4)	0.634	(4)	0.467	(2)
Thymus	0.539	(4)	0.671	(1)	0.753	(1)	0.464	(4.5)
Fumana	0.163	(10)	0.103	(10)	0.084	(10)	0.231	(10)
Euphorbia	0.290	(9)	0.443	(5)	0.512	(6)	0.261	(9)
Carex	0.509	(7)	0.434	(6)	0.544	(5)	0.464	(4.5)
Minuartia	0.443	(8)	0.253	(8)	0.228	(8)	0.467	(3)
Cynodon	0.512	(5)	0.621	(2)	0.680	(2)	0.402	(8)
Equisetum	0.617	(1)	0.331	(7)	0.440	(7)	0.455	(6)
Centaurea	0.578	(2)	0.189	(9)	0.209	(9)	0.481	(1)

Rank numbers are in brackets

Table 25

Distribution of species frequencies in the categories of soil moisture content and root depth

Species \ mS / cm	0.1—0.29					0.30—0.49					0.50—0.69					0.70—0.89					0.90—				
	2—3.9	4—5.9	6—7.9	8—9.9	10—	2—3.9	4—5.9	6—7.9	8—9.9	10—	2—3.9	4—5.9	6—7.9	8—9.9	10—	2—3.9	4—5.9	6—7.9	8—9.9	10—	2—3.9	4—5.9	6—7.9	8—9.9	10—
Festuca		4	2				3	3				1	2	1		1		2				1			
Medicago		1				1	1	1			5		1				2								
Thymus	2	1				1	2	1			1	1	2									1			
Fumana										1				1	1					2				2	4
Euphorbia			1				1							1				1	1	1			1	2	2
Carex	1	2	1			2	2				2					1									
Minuartia	1					4					2	1													
Cynodon		2						1					1		1										
Equisetum		2					1	1																	
Centaurea			1										1					1							
Sum	4	12	5			8	10	7		1	10	3	7	3	2	2	2	4	1	3		2	1	4	6

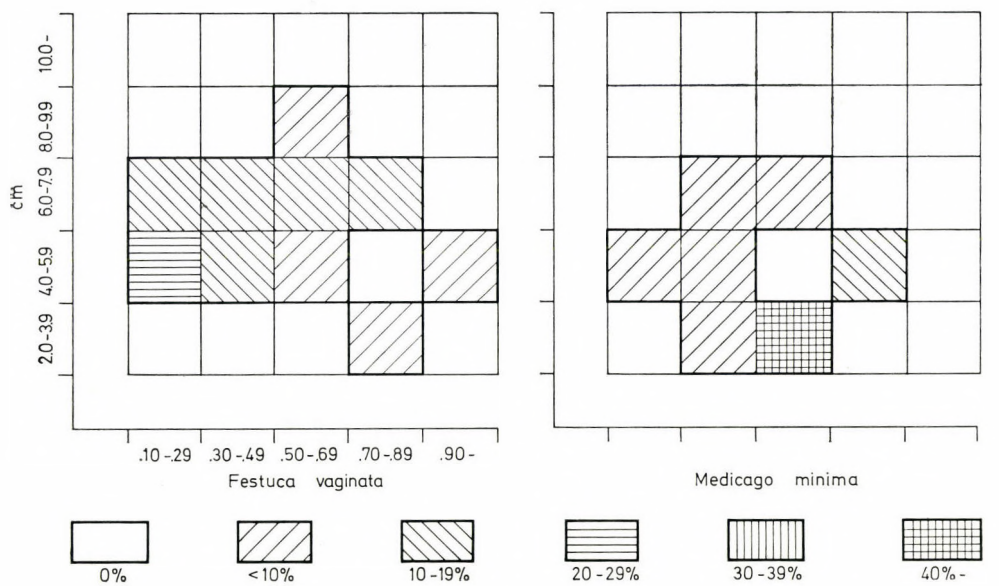
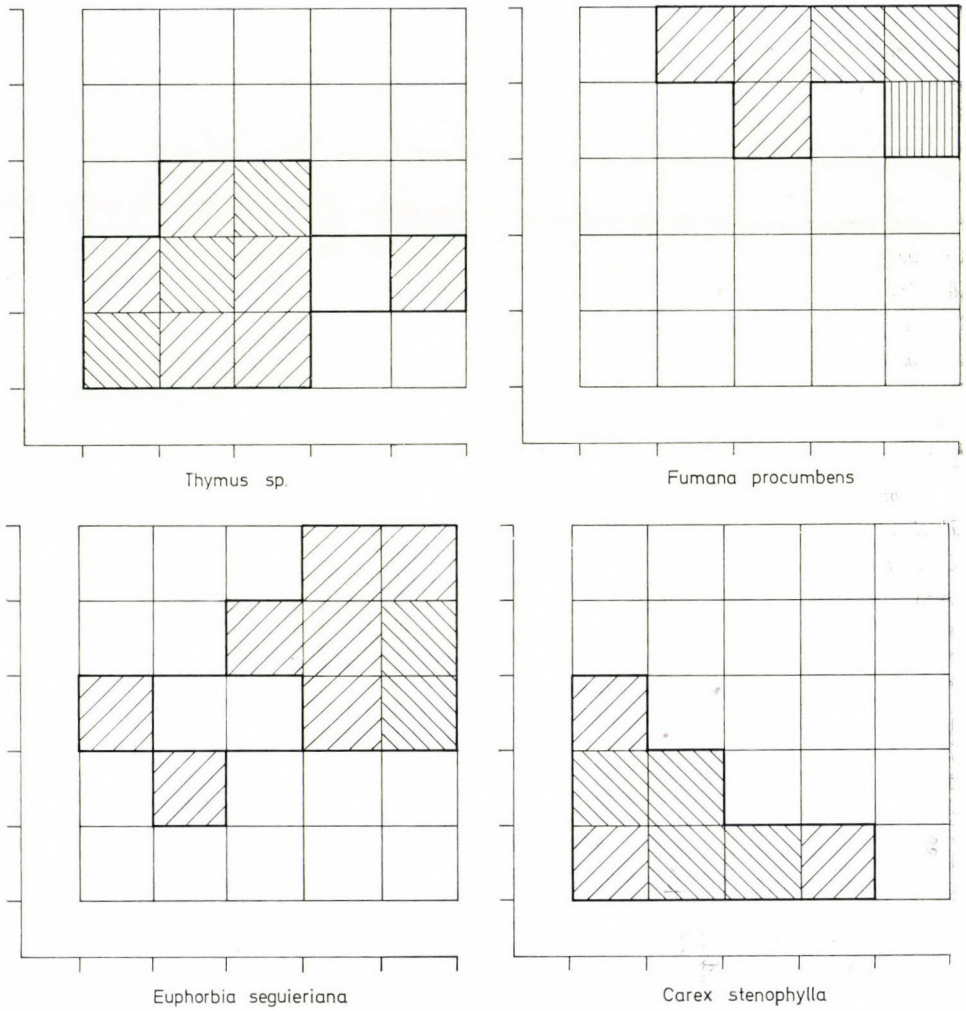


Fig. 10. Position of the species in the system of co-ordinates formed by the soil moisture and root depth axes
Hatching pattern indicates frequency

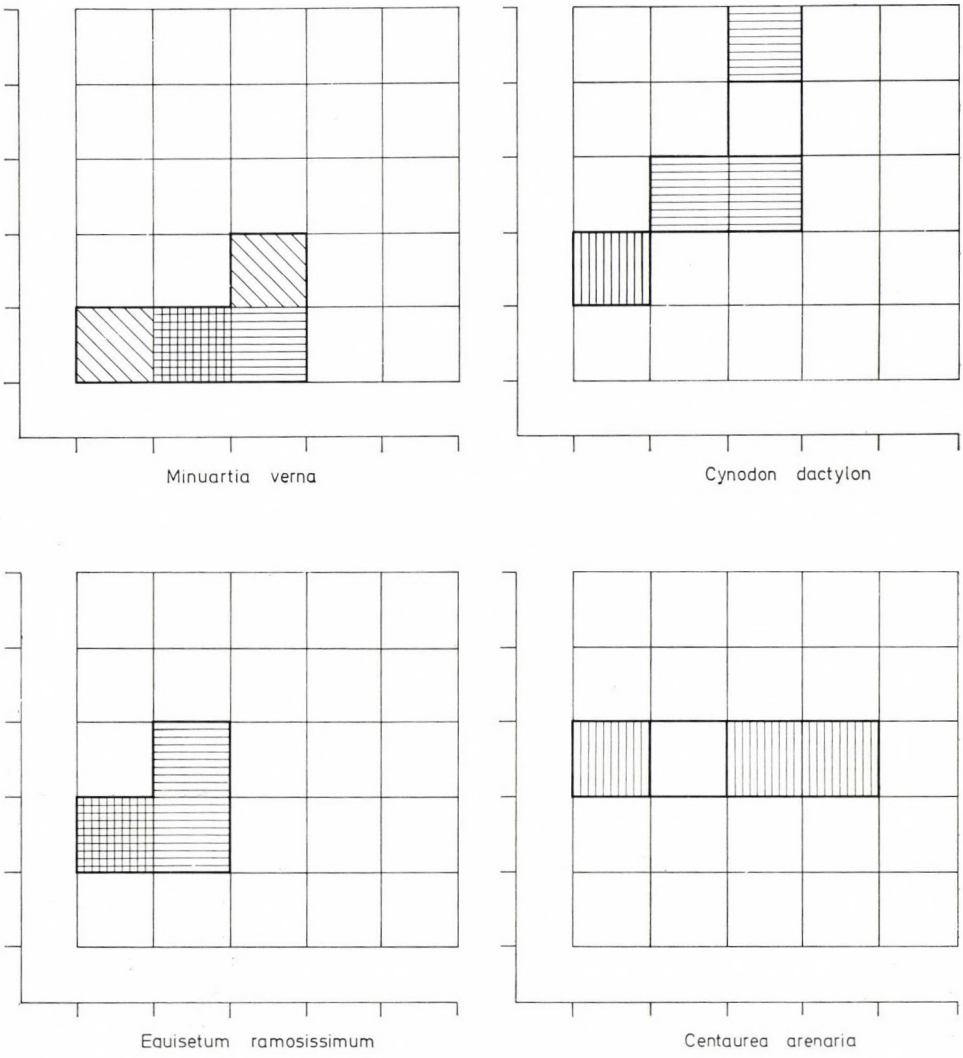


moisture content: the sequence of species is highly deviating in a comparison between the weighted and the non-weighted values; this holds for both the species effect and the community effect (Table 24).

The species frequency, according to the combined categories of soil moisture content and root depth is shown in Table 25 and in Fig. 10. In this case we only worked with the original frequencies.

Festuca has the greatest niche breadth, while *Equisetum* has the smallest one (Table 26).

The average of the overlaps calculated by using measurement C_{hi} and R_{hi} gave an almost identical order. The value of *Festuca* is the greatest also in this case. The smallest value occured in *Fumana*. The averages of the *d*-values



according to species (Table 27), or more exactly the reversed order of the category numbers, produced an order very near to that of the overlap averages (Table 28).

The distribution of the overlap values (calculated on the basis of combined categories) can be studied on two measurements (C_{hi} and R_{hi}) (Table 29). In both of them, the value 0 is the most frequent, where the two frequency distributions are rather different. In any case, they are more similar to the distribution according to root depth (Table 18) than to that according to soil moisture content (Table 17).

Table 26

Niche breadths and overlaps
Combination of soil moisture content and root depth

	Festuca	*Medicago*	*Thymus*	*Fumana*	*Euphorbia*	*Carex*	*Minuartia*	*Cynodon*	*Equisetum*	*Centaurea*
Festuca	*0.677*	0.421	0.645	0.069	0.370	0.520	0.083	0.638	0.769	0.643
Medicago	0.332	*0.527*	0.642	0.000	0.088	0.623	0.394	0.455	0.521	0.185
Thymus	0.516	0.499	*0.664*	0.000	0.120	0.654	0.573	0.505	0.579	0.254
Fumana	0.050	0.000	0.000	*0.510*	0.648	0.000	0.000	0.140	0.000	0.000
Euphorbia	0.323	0.084	0.133	0.545	*0.666*	0.216	0.000	0.000	0.159	0.381
Carex	0.473	0.432	0.509	0.047	0.184	*0.588*	0.617	0.279	0.538	0.191
Minuartia	0.050	0.333	0.374	0.000	0.000	0.454	*0.377*	0.000	0.000	0.000
Cynodon	0.450	0.249	0.333	0.091	0.000	0.182	0.000	*0.414*	0.673	0.262
Equisetum	0.500	0.249	0.333	0.000	0.091	0.363	0.000	0.600	*0.323*	0.000
Centaurea	0.300	0.084	0.168	0.000	0.183	0.093	0.000	0.200	0.000	*0.341*

In the main diagonal value H_i, in the upper matrix R_{hi}, in the lower matrix value C_{hi}

Table 27

The Euclidean distance (d) between the species
Combination of soil moisture content and root depth

	Medicago	*Thymus*	*Fumana*	*Euphorbia*	*Carex*	*Minuartia*	*Cynodon*	*Equisetum*	*Centaurea*
Festuca	1.212	0.951	1.396	1.211	0.996	1.395	0.855	0.724	1.051
Medicago		0.550	1.414	1.350	0.861	0.988	1.217	1.200	1.342
Thymus			1.414	1.325	0.838	1.047	1.053	1.019	1.206
Fumana				0.714	1.414	1.414	1.362	1.414	1.414
Euphorbia					1.282	1.414	1.414	1.338	1.185
Carex						0.853	1.143	0.936	1.317
Minuartia							1.414	1.414	1.414
Cynodon								0.676	1.250
Equisetum									1.414

The sequence of the niche breadths, calculated on the basis of index B_i (Table 30), shows no other agreement with the order according to the H_i function than the niche breadth of *Equisetum* being the narrowest also by this calculation.

On the basis of the community matrix (Table 30), the community effect is the greatest in the case of *Festuca* and the smallest in *Fumana*. The species effect is the greatest in *Equisetum* and the lowest in *Fumana* (Table 31).

Table 28

Species average niche overlap order
Combination of soil moisture content and root depth

Measurement / Species	C_{hi}	R_{hi}	d^*
Festuca	1	1	1
Medicago	4	4	5
Thymus	2	2	2
Fumana	10	10	10
Euphorbia	7	7	7
Carex	3	3	3
Minuartia	8	9	8
Cynodon	6	6	4
Equisetum	5	5	6
Centaurea	9	8	9

* Starting from the smallest distance

Table 29

Distribution of niche overlap values
*Soil moisture content and root depth**

Measurement / Class*	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0
C_{hi}				1	4	5	8	3	5	19
R_{hi}			1	9	6	2	3	4	5	15

* See also Table 17

Table 30

Community matrix
*Combination of soil moisture content and root depth**

	Festuca	*Medicago*	*Thymus*	*Fumana*	*Euphorbia*	*Carex*	*Minuartia*	*Cynodon*	*Equisetum*	*Centaurea*
Festuca	*8.064*	0.395	0.645	0.040	0.298	0.620	0.048	1.048	1.419	0.798
Medicago	0.209	*4.273*	0.358	0.000	0.034	0.512	0.623	0.286	0.358	0.119
Thymus	0.634	0.666	*7.936*	0.000	0.119	0.714	0.746	0.658	0.667	0.444
Fumana	0.022	0.000	0.000	*4.504*	0.554	0.000	0.000	0.081	0.000	0.000
Euphorbia	0.301	0.065	0.121	1.000	*8.130*	0.195	0.000	0.000	0.186	0.487
Carex	0.493	0.769	0.577	0.000	0.153	*6.410*	0.940	0.461	0.871	0.192
Minuartia	0.017	0.424	0.273	0.000	0.000	0.427	*2.907*	0.000	0.000	0.000
Cynodon	0.541	0.279	0.345	0.075	0.000	0.300	0.000	*4.166*	1.041	0.279
Equisetum	0.470	0.224	0.224	0.000	0.061	0.363	0.000	0.668	*2.674*	0.000
Centaurea	0.297	0.084	0.168	0.000	0.180	0.090	0.000	0.201	0.000	*3.003*

* See also Table 19

Table 31

Species effect and community effect
Combination of soil moisture content and root depth

Species	Species effect	Community effect
Festuca	0.332 (4)	0.590 (1)
Medicago	0,323 (5)	0.278 (5)
Thymus	0.301 (6)	0.516 (2)
Fumana	0.124 (10)	0.073 (10)
Euphorbia	0.155 (9)	0.262 (6)
Carex	0.358 (3)	0.495 (3)
Minuartia	0.262 (7)	0.127 (8)
Cynodon	0.378 (2)	0.318 (4)
Equisetum	0.505 (1)	0.223 (7)
Centaurea	0.258 (8)	0.113 (9)

Rank numbers in brackets

Table 32

D-analysis results

	Medicago	*Thymus*	*Fumana*	*Euphorbia*	*Carex*
Festuca	0.611	0.496	1.508***	1.094**	0.856*
Medicago		0.240	1.632***	1.319**	0.662
Thymus			1.491***	2.234***	0.281
Fumana				0.539	0.821*
Euphorbia					2.267***

For remarks see Table 7

D-analysis was made only in *Festuca, Medicago, Thymus, Fumana, Euphorbia* and *Carex,* on the basis of soil moisture content and root depth by using the original measurement data. By taking into consideration the two characteristics together, it can be stated that the distance is small between the niche centres of *Festuca—Medicago—Thymus, Medicago—Carex—Thymus* and *Fumana—Euphorbia* (Table 32).

Summary

For a comparison between various measurements we used rank correlations of the species obtained on the basis of the above mentioned measures, Without doubt, the comparison is possible also in other ways. For example, the functions H_i and $H_{i,w}$, according to the soil moisture content, did not correlate, even though the differences between the value pairs according to the two functions are not great. It can be attributed to the fundamental differences between the measurement that in many of the cases it is not the various weighted measures that show agreement according to the correlations, but, for example, a weighted measure with anunweighted formula of other origin. As has been mentioned, LEVINS's index B_i estimates, according to rank correlations, the most satisfactorily all breadth orders obtained by the other measurements and for that matter in both niche dimensions.

In the order of sequence of the PIELOU-type weighted niche breadths, the value between the first and the last species deviates with one order of magnitude. The index $u_i h_i(b)$ takes dominance into consideration, blurred in the other measurements. Thus the PIELOU-type weighting is sensitive to something else than that of the COLWELL-FUTUYMA-type: the former to species representation, the latter to categories.

The deviating nature of the various measurements manifests itself also in the overlap-values. This is well reflected from the compilations which indicate the frequency distribution of the overlap values (45—45) according to the various measurements. A measurement characteristic is for example that HORN's R_{hi} (and the $R_{hi,w}$) give a high value (≥ 0.7) in considerably more cases than do the indices C_{hi} (and $C_{hi,w}$) In any case, all measurements give the identical results for the average overlap value (the overlap average of one species in relation to all the others), it being the greatest in the case of *Festuca*, and the smallest in the that of *Fumana*, on the soil moisture content axis. On the root depth axis, all measurement showed the greatest average overlap in *Thymus*, and the smallest one in *Fumana*, while, according to the combined categories, *Festuca* is at the beginning of the sequence and *Fumana* at its end.

The two-dimensional presentation of the niches is to be found already in HUTCHINSON's works (1957, 1967), but the calculation of the parameters by our approach (on the basis of combined categories) has hardly any previous example. The expression of breadth and overlap according to factor combinations is more natural than that made on separate axes, for it is likely that the fitting into the community, the competition on all scales, takes place simultaneously (if they are indeed relevant). The niche breadths according to the combined categories mostly follow the pattern of niche breadth of the root depths. The community effect calculated on the basis of the combined

categories also takes an almost identical pattern with root depth. The sequence of species effect is also similar to that according to the root depth.

Following from the character of this paper, we do not propose to discuss the analysis of the species effect and community effect according to species or niche dimensions. The community effect directed to a species h is in some way dependent on the niche breadth of the species examined, since

$$\alpha_{hi} = \sum_j p_{hj} p_{ij} / \sum_j p_{hj}^2 = \sum_j p_{hj} p_{ij} \cdot B_h$$

where B_h is the niche breadth (LEVINS, 1968). The values, and finally the community effect values, depend on the magnitude of the values p_h and p_i, but mainly on their distribution. The community effect can be very low for a species of medium niche breadth (for example, *Fumana*, according to the combined categories), since *Fumana* is an "ecological specialist": it prefers categories where all other species occur only with a small frequency (or do not at all).

REFERENCES

ARES, J. O. (1972): Equitability, competition and seasonal succession in a plant community. J. Ecol., **66,** 325—331.

ARES, J. O.—LEON, R. J. C. (1972): An ecological assessment of the influence of grazing on plant community structure. J. Ecol. **66,** 333—342.

CAIN, A. J. (1969): Speciation in tropical environments: summing up. In: LOWE, R. H.—MCCONNELL, ed.: Speciation in tropical environments. New York.

CASTENHOLZ, R. W. (1968): The behavior of Oscillatoria terebriformis in hot springs. J. Phycol. **4,** 132—139.

CLARKE, G. L. (1954): Elements of ecology. WILEY, New York, 560 pp.

COLWELL, R. K.—FUENTES, E. R. (1975): Experimental studies of the niche. Ann. Rev. of Ecology and Systematics, **6,** 281—310.

COLWELL, R. K.—FUTUYMA, D. J. (1971): On the measurement of niche breadth and overlap. Ecology **52,** 567—576.

DICE, L. R. (1952): Natural communities. Univ. Michigan Press, Ann Arbor, 547 pp.

ELTON, C. S. (1927): Animal ecology. SIDGWICK and JACKSON, London, 209 pp.

FEKETE, G. (1974): Interspecifikus kapcsolatok, költcsönhatások és az ökológiai niche elemzése tölgyerdei fajokon. Akadémiai doktori értekezés (Interspecific connections, correlations and the analysis of the ecological niche in oakwood species. (Doctor's thesis). Budapest, 282. pp. Mscr.

FEKETE, G.—SZUJKÓ-LACZA, J. (1973): Interspecific correlation of plants in oakwood at increasing block sizes. Acta Biol. Acad. Sci. Hung. **24,** 31—42.

FRANKIE, G. W.—BAKER, H. G.—OPLER, P. A. (1974): Comparative phenological studies of trees in tropical wet and dry forests in the lowlands of Costa Rica. J. Ecol. **62,** 881—919.

GREEN, R. H. (1971): A multivariate statistical approach to the Hutchinsonian niche: bivalve mollusc of Central Canada. Ecology **52,** 543—556.

GRINNELL, J. (1917): The niche relationship of the California trasher. Auk **21,** 364—382.

HARPER, J. L. (1969): The role of predation in vegetational diversity. In: WOODELL and SMITH, eds: Diversity and stability in ecological systems. Brookhaven Symp. Biol., **22,** 48—62.

HARPER, J. L.—CHATWORTHY, J. N. (1963): The comparative biology of closely related species VI. Analysis of the growth of Trifolium repens and T. fragiferum in pure and mixed populations. J. Exp. Bot. **14,** 172—190.

HORN, H. S. (1966): Measurement of "overlap" in comparative ecological studies. The American Naturalist, 100, 419—424.

HUTCHINSON, G. E. (1957): Concluding remarks. Cold Spring Harbor Symp. Quant. Biol. **22,** 415—427.

HUTCHINSON, G. E. (1967): A treatise on limnology. Vol. *II*, Introduction to lake biology and the limnoplankton. WILEY, New York, 1115 pp.

JANZEN, D. H. (1967): Synchronization on sexual reproduction of trees within the dry season in Central America. Evolution, **21,** 620—637.

JUHÁSZ-NAGY, P. (1968): Terepkísérletek a rétek hozamának vizsgálatára. A VIII. Biológiai Vándorgyűlés előadásainak ismertetése (Field experiments with regard to the yields of the meadows. Review of the lectures delivered at the Eighth Biological Itinerary Congress). Gödöllő, 1968. V. 23—25, p. 16.

KALLIS, A.—TOOMING, H. (1975): Some considerations on the use of information analysis in studying the structure of plant communities depending on PhAR regime. In: Some aspects of botanical research in the Estonian S. S. R. 169—187.

KÁRPÁTI, I.—KÁRPÁTI, V. (1954): The aspects of the calciphilous turf (Festucetum vaginatae danubiale) in the environs of Vácrátót in 1952. Acta Bot. Acad. Sci. Hung. **1,** 129—157.

KRUCKEBERG, A. R. (1954): The ecology of serpentine soils. Ecology **35,** 267—274.

LEVINS, R. (1968): Evolution in changing environment. Princeton, New Jersey, 120 pp.

LLOYD, M.—GHELARDI, R. J. (1964): A table for calculating the "equitability" component of species diversity. J. Anim. Ecol. **33,** 217—225.

MACARTHUR, R. H. (1957): On the relative abundance of bird species. Proc. Nat. Acad. Sci. **43,** 293—295.

MACARTHUR, R. H.—LEVINS, R. (1967): The limiting similarity, convergence, and divergence of coexisting species. The American Naturalist, **101,** 377—385.

MAGUIRE, B. (1973): Niche response structure and the analytical potentials of its relationship to the habitat. The American Naturalist **107,** 213—246.

MCMILLAN, C. (1959): Salt tolerance within a Typha population. Amer. J. Bot. **46,** 521—526.

MCNAUGHTON, S. J.—WOLF, L. L. (1970): Dominance and the niche in ecological systems. Science **167,** 131—139.

MCNAUGHTON, S. J.—WOLF, L. L. (1973): General ecology. HOLT, RINEHART and WINSTON, New York—Sydney, 710 pp.

MILLER, R. S. (1967): Pattern and process in competition. Adv. Ecol. Res. **4,** 1—74.

MOORE, C. W. E. (1959): Interaction of species and soil in relation to the distribution of eucalypts. Ecology, **40,** 734—735.

NOSEK, J. N. (1976): Comparative analysis of some diversity functions under different conditions of sampling in sandy meadows. Acta Bot. Acad. Sci. Hung. **22,** 415—436.

ORLÓCI, L. (1967): An agglomerative method for classification of plant communities. J. Ecol. **55,** 193—205.

PEET, R. K. (1974): The measurement of species diversity. Ann. Rev. Ecol. Syst. **5,** 285—307.

PIANKA, E. R. (1972): Evolutionary ecology. HARPER—ROW, New York—London, 334 pp.

PICKETT, S. T. A.—BAZZAZ, F. A. (1976): Divergence of two co-occurring successional annuals on a soil moisture gradient. Ecology **57,** 169—176.

PIELOU, E. C. (1967) The use of information theory in the study of the diversity of biological populations. Proc. Fifth Berkeley Symp. on Mathemat. Statistics and Probability, **IV.,** 163—177.

PIELOU, E. C. (1972): Niche width and niche overlap: a method for measuring them. Ecology **53,** 687—692.

PIELOU, E. C. (1975): Ecological diversity. WILEY, New York—Toronto, 165 pp.

PULLIAM, H. R.— ODUM, E. P.—BARRETT, G. W. (1968): Equitability and resource limitation. Ecology **49,** 772—774.

PUTWAIN, P. D.—HARPER, J. L. (1970): Studies on the dynamics of plant populations. III; J. Ecol. **58,** 251—264.

ROGERS, J. A.—KING, J. (1972): The distribution and abundance of grassland species in hill pasture in relation to soil aeration and base status. J. Ecol. **60,** 1—18.

SCHOENER, T. W. (1970): Nonsynchronous spatial overlap of lizards in patchy habitats. Ecology **51,** 408—418.

SHUGART, H. H. jr.—PATTEN, B. C. (1972): Niche quantification and the concept of niche pattern. In: PATTEN, B. C. ed.: Systems analysis and simulation in ecology, Vol. **II** Acad. Press, New York, pp. 283—327.

SMYTHE, N. (1970): Relationship between fruiting seasons and seed dispersal methods in a neotropical forest. The American Naturalist **104,** 25—35.

SOÓ, R. (1957): Conspectus des groupements végétaux dans les Bassins Carpathiques. Acta Bot. Acad. Sci. Hung. **3,** 43—64.

TADROS, T. M. (1957): Evidence of the presence of an edapho-biotic factor in the problem of serpentine tolerance. Ecology **38,** 14—23.
VANDERMEER, J. H. (1972a): Niche theory. Ann. Rev. Ecol. Syst. **3,** 107—132.
VANDERMEER, J. H. (1972b): On the covariance of the community matrix. Ecology **53,** 187—189.
WHITTAKER, R. H. (1965): Dominane and diversity in land plant communities. Science **147,** 250—260.
WHITTAKER, R. H. (1972): Evolution and measurement of species diversity. Taxon **21,** 213—251.
WHITTAKER, R. H. (1975): Communities and ecosystems. II. ed. COLLIER—MACMILLAN, New York—London, 385. pp.
WHITTAKER, R. H.—FAIRBANKS, C. W. (1958): A study of plankton copepod communities in the Columbia Basin, southeastern Washington. Ecology **39,** 46—65.
WHITTAKER, R. H.—LEVIN, S. A.—ROOT, R. B. (1973): Niche- habitat, and ecotope. The American Naturalist, **107,** 321—337.
WOODELL, S. R. J.—MOONEY, H. A. (1975): The adaption to serpentine soils in California of the annual species Linanthus androsaceus (Polemoniaceae). Bull. Torrey Bot. Club **102,** 232—238.
WUENSCHER, J. E. (1969): Niche specification and competition modelling. J. Theoret. Biol. **25,** 436—443.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (3—4), pp. 355—360 (1976)

CLAVATOSPORA FLAGELLATA SP. NOV. AN AQUATIC HYPHOMYCETE FROM HUNGARY

By

J. GÖNCZÖL

BOTANICAL DEPARTMENT, HUNGARIAN NATURAL HISTORY MUSEUM, BUDAPEST

(Received November 17, 1976)

Clavatospora flagellata sp. nov. is described from submerged decaying leaves. The development on its natural substrate, the seasonal frequency and distribution of the fungus are also discussed and illustrated.

The conidia of the fungus described here have already occurred in the winter foam-sample collected in the upper reach of the river-system of Morgó-brook (Mts. Börzsöny, Northern Hungary) under study for some years. During the winter investigations in 1974, a few skeletonized leaves were collected with a fungus growing among and very similar to the well-known specimens of *Alatospora acuminata* Ingold.

In the same period of the next year, more leaf material could be collected and the fungus, known until then by its conidia only, was successfully cultivated on its natural substrate and observed during its development.

Spore production of the present species was observed on submerged decaying leaves of *Fagus silvatica, Carpinus betulus* and *Quercus* sp., collected in November, December and January. Skeletonized leaves were placed in Petri-dishes filled with distilled water, and in an aquarium filled with brook water. Both the Petri-dishes and the aquarium were aerated and kept about 5°C. In the strongly aerated cultures, the developing specimens appeared on the third day. Many skeletonized leaves were examined during the winter investigational period (November—January) and it was found that the present fungus appeared only very sparsely on each leaf. Almost always single conidiophores were to be seen on the leaves.

The present fungus, together with *Monotosporella tuberculata* Gönczöl described recently, is one of the most characteristic species of the Aquatic Hyphomycetes in the montane streams of the beech region in Hungary. This fungus, similarly to *Monotosporella tuberculata,* is definitely a winter species having its sporulation peak in December—January with water temperature about 0°C (GÖNCZÖL, 1975).

Clavatospora flagellata sp. nov. (Figs 1—2)

Fungus hyphis hyalinis, septatis, ad folia putrida in aqua submersa. Conidiophora hyalina, septata, plerumque brevissima, 15—25 (50) × 3—3.5 μm, simplicia vel ramosa, phialides acrogenis plerumque 2 vel raro 3. Conidia (phialosporae) hyalina, cylindraceo-fusoidea,

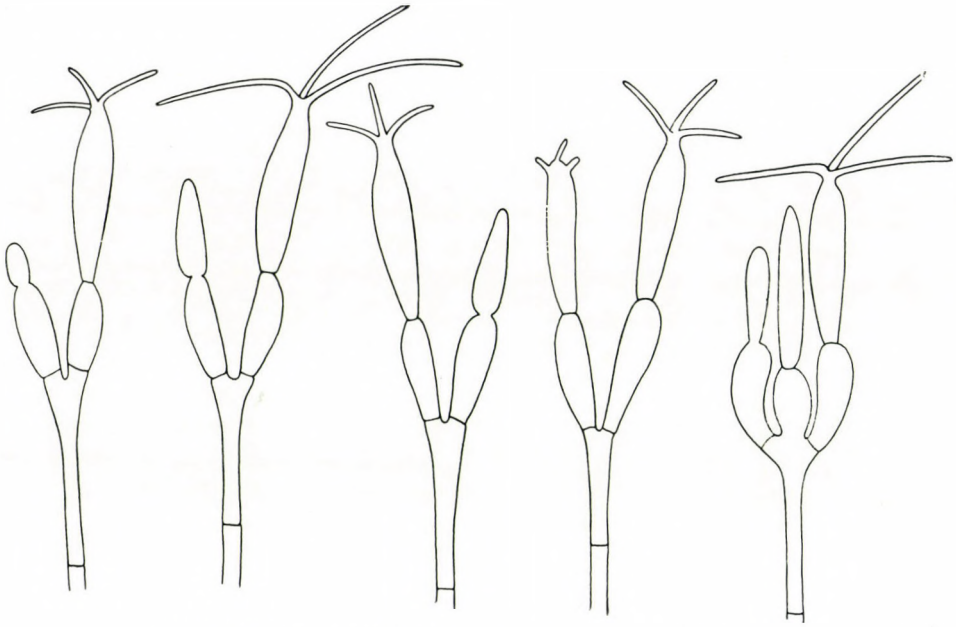


Fig. 1. Clavatospora flagellata sp. nov. spore production

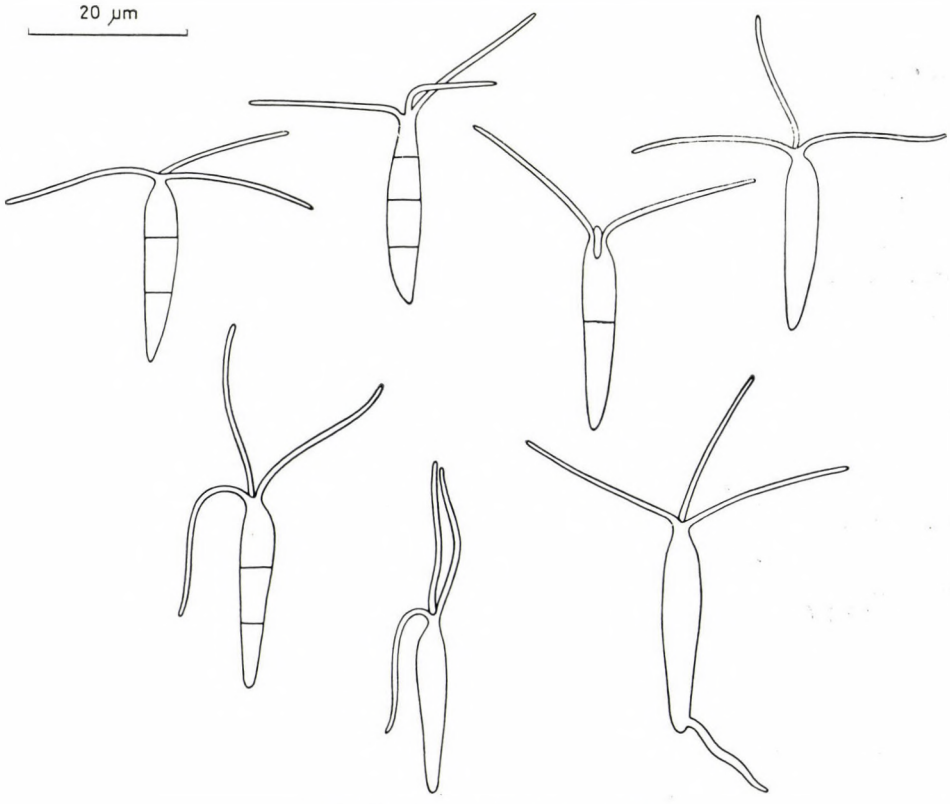


Fig. 2. Liberated mature conidia

aseptata, rarius 1—3 septata, 23—26 (30) × 3.5—4 μm, in apice appendicibus plerumque 3, raro 4, semperarcuatis et flexibilibus, nunquam rectis et rigidis aequabiliter crassis, 25—30 × 1.4—1.6 μm.

Habit. in foliis *Fagi silvaticae*, *Carpini betuli* et *Quercus* sp. in aqua submersis putridisque. Typus: in rivulo Szénpatak prope Királyrét, Mts. Börzsöny, Hungaria, 15. 1. 1975., leg. J. GÖNCZÖL, in Herb. Mus. Hist.-nat. Hung. Budapest.

On the natural substrate, the mycelium and conidiophores are hyaline, septate, 3—3.5 μm thick. The conidiophores were short in the majority of the specimens observed. Frequently, only the phialide rose out of the surface of the substrate (leaf vein) (Plate I, 1—5). The longer conidiophores, found on some occasions, were 35—40 (max. 50) μm long together with the phialide. The phialide is cylindrical-oval, thickening slightly in its upper third.

One or two phialides are usually developing on the conidiophores, but they may be rarely branched with three phialides (Plate I, 7).

The conidium begins its development as a small swelling at the end of the phialide and soon becomes cylindrical-fusiform. The fusiform shape is hardly acuminate, being the thickest sometimes in the lower, and sometimes in the upper third, but never truly clavate. The three, rarely four, simultaneously developing processes appear when the main part of the conidium reaches the length of 15—20 μm. The processes characteristically originate as straight continuations of the main part of the conidium, and then become incurved and divergent. They are never rigid and straight, but flagellatelly flexible, readily bending when the cover slide is tapped.

The processes are 1.4—1.6 μm wide, as long as the main part of the conidium, hardly tapering apically. The mature conidia are colourless, 23—26 (max. 30) × 3.5—4 μm. The granulosity of the cytoplasm is often conspicuous, as e.g. the conidium of *Jaculispora submersa* Hudson et Ingold. In some of the conidia bigger, circular or irregularly shaped, dark granules are visible. Sometimes four or six such granules can be observed, almost wholly filling the main part of the conidium (Plate II, 6).

Most conidia are unicellular, however, there recur regularly conidia with 1—3 very pale septa. Germinating conidia can hardly be found among the numerous conidia in the foam-samples. So far, germination could be observed in no more than two case. The germ tube started from the basal end of the conidia.

Discussion

When classifying the present species, two genera with phialosporae were considered, viz. *Alatospora*, Ingold and *Clavatospora* S. Nilsson. The conidium of *Clavatospora flagellata* sp. nov. resembles the conidium of *Alatospora acuminata* Ingold, yet the former has no main axis, although any one of its processes may appear as a continuation of the main part of the conidium.

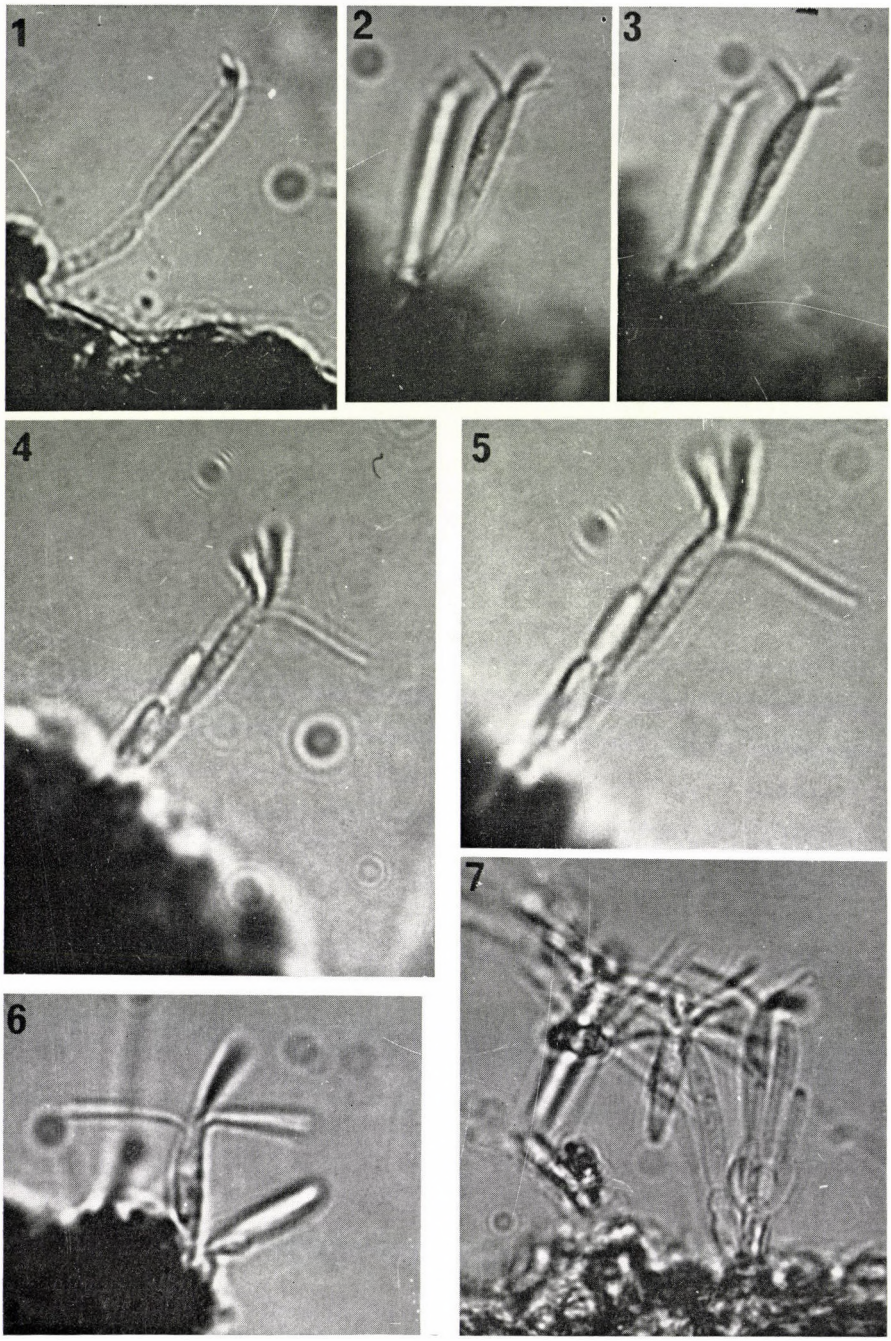


Plate I

1—6. Developing conidia on submerged *Fagus silvatica* leaf (1000×)
7. Developing conidia on a conidiophore with three phialides (1000×)

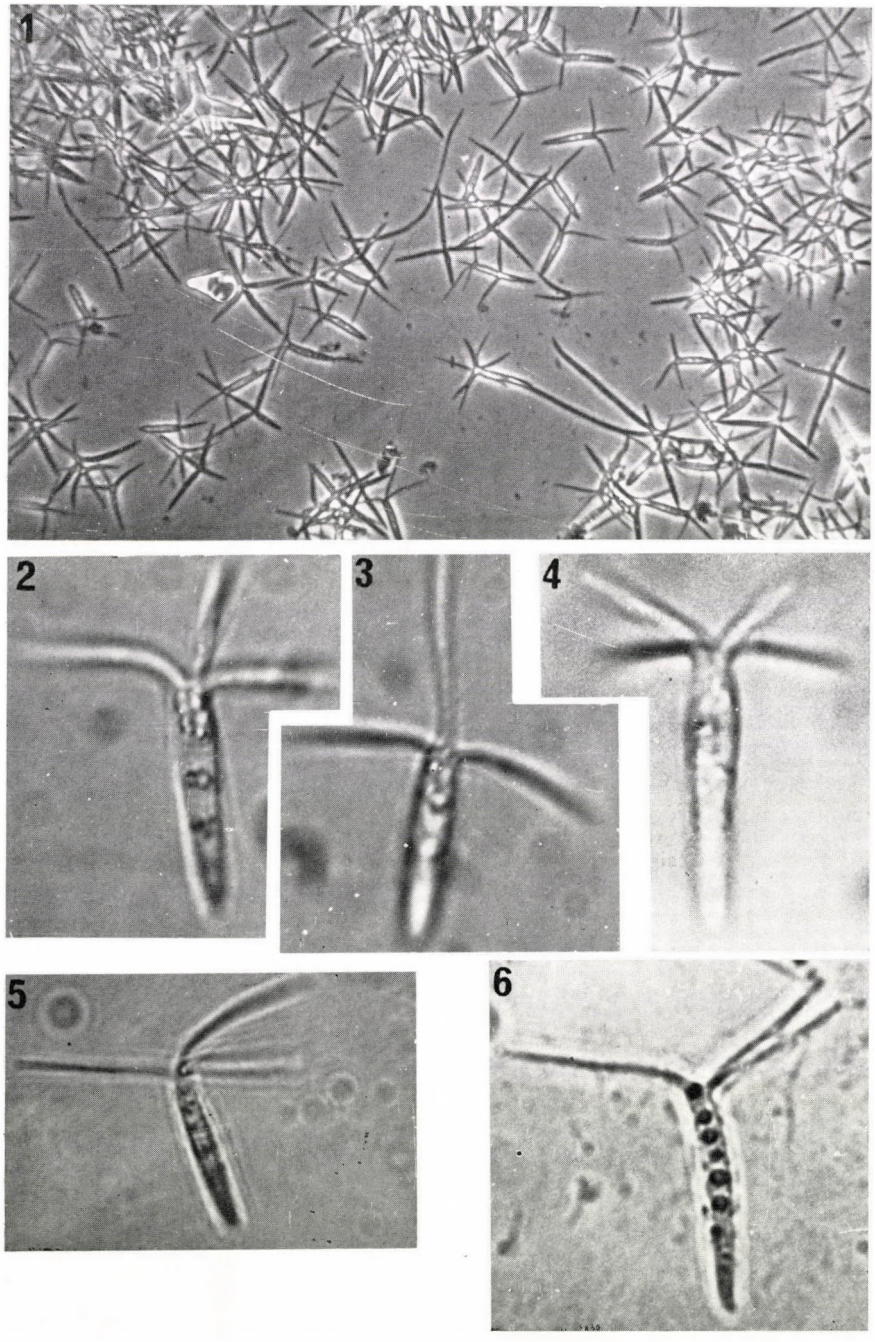


Plate II

1. Liberated conidia of *Clavatospora flagellata* sp. nov. from a foam-sample in December (240 ×)

2—4. Liberated young conidia of *Clavatospora flagellata* sp. nov. (800 ×, 1200 ×)

5—6. Liberated mature conidia from a foam sample (700 ×, 1000 ×)

The liberated and mature conidia of the present species resemble the conidia of *Alatospora acuminata*, especially when one of its three processes, namely the median one which lies in the same level of the main part, forms a common arc with it (Plate II, 6). In samples where the conidia of *Clavatospora flagellata* sp. nov. occur mixed with those of *Alatospora acuminata*, the new species imitates strinkingly the conidium of *Alatospora acuminata* (Plate II, 1). However, under a higher magnification, the morphological differences between the conidia become well visible (Plate II, 2—6). While the four arms of the conidium of *Alatospora acuminata* are of equal width, the conidium of *Clavatospora flagellata* sp. nov. appear as a conidial trunk with three equal processes. Therefore similarly to the genera *Clavatospora* and *Clavariopsis*, the conidium has radiately symmetrical but characteristically formed processes.

On the basis of these characteristics its relegation to *Clavatospora* seems justified, although the main part of the conidium is not markedly clavate, but rather cylindrical-fusiform or occasionally resembling a taproot. A further difference is the occurence of 1—3 septa in some conidia. Because of these differences as well as the peculiarly originating whip-like processes, the new species differs from the known species of *Clavatospora*. It may possibly represent also a new genus.

Comparison of the main features of the conidia of *Clavatospora longibrachiata* (Ingold) S. Nilsson and of *Clavatospora flagellata* sp. nov.

	Cl. longibrachiata	*Cl. flagellata* sp. nov.
Conidium trunk	wedge-shaped, one-celled	cylindrical-fusiform or slightly clavate 1—(4) celled
Process	straight, rigid, 3	curved, flexibile, 3, (4)

ACKNOWLEDGEMENTS

The author wishes to thank Dr. Sándor TÓTH (University of Agrarian Sciences, Gödöllő, Hungary) for the Latin diagnosis and for his valuable advice and notes.

REFERENCES

GÖNCZÖL, J. (1975): Ecological observations on the Aquatic Hyphomycetes of Hungary I. Acta Bot. Acad. Sci. Hung. **21,** 243—264.

GÖNCZÖL, J. (1976): Monotosporella tuberculata, a new species of Aquatic Hyphomycetes from Hungary. Nova Hedwigia **27,** 493—500.

INGOLD, C. T. (1942): Aquatic Hyphomycetes of decaying alder leaves Trans. Brit. mycol. Soc. **25,** 339—417.

NILSSON, S. (1964): Freshwater Hyphomycetes. Taxonomy, morphology and ecology. Symb. Bot. Upsal. **18,** 5—130.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (3—4), pp. 361—365 (1976)

ON THE THICK-SPINED SPECIES OF MICRACTINIUM

By

T. HORTOBÁGYI

DEPARTMENT OF BOTANY, UNIVERSITY OF AGRICULTURAL SCIENCES, GÖDÖLLŐ, HUNGARY

(Received September 25, 1976)

In the years 1971—73 I observed three *Micractinium* species with unusually thick spines in the River Danube (Hungary). One was published as *Micractinium crassisetum* Hortob. (p. 123) in 1973. My recent observations complement my earlier description. Diameter of cells 5.5—9 μ; the hollow, rigid, unusually thick-walled, sharply pointed spines 24.7—60 μ, long, their basal breadth 1.7—2.8 μ.

A species of similar construction is *Micractinium strigoniense* Hortob. It differs from the preceding one by having one thick-walled spine on each cell with two thin-walled small spines, situated on both sides of the former. Cell diameter 5—5.5 μ, length of spines 30—33 μ, shorter ones 16—19 μ; the former have a basal breadth of 1.6—1.8 μ, the latter 0.3—0.4 μ. Composed of features characteristic to *M. pusillum* Fresen and *M. crassisetum* Hortob.

The third species is *M. conococcoides* Hortob., with one thick-walled spine on each cell, and a broad base. Cell diameter 6—7 μ, length of spines 47—51 μ, basal breadth 2.5—3 μ.

All three species are with cells in agglomerations and not arranged in a plane.

In the course of examination of the microscopic vegetation in the settling and enriching dressing basins, I have identified 415 taxa from the collections made in 1968—1969. The respective taxa were highly diverse as regards space and thime in the formation of the coenosis. This fact can be explained partly by the great number of organisms, different ecological spectra and partly by the permanent connection to the Danube and by the various environmental factors. Most taxa, valuable from a saprobiological viewpont, are beta- and mesosaprobic: they reflect the state of the Danube as a good feeding water. Among the 158 assessed organisms there are 3 oligosaprobionts, 34 oligo-beta-saprobionts, 65 beta-mesosaprobionts, 49 beta-alpha-mesosaprobionts, 6 alpha-saprobionts and 1 polysaprobiont.

In the course of examination of the indicator organisms, taxa with very thick spicules have been very sticking. I had already mentioned, as early as in my Indian and Viet-Namese publications, that the occurrence of some organisms in more southern regions as well as the state of trophisation may be connected with a more robust and larger stature and principally with a bigger and thicker appearance of the spicules.

In my studies on the Danube, I emphasized the unusually thick coenobia with obtuse spicules, occurring in the genus Scenedesmus.

The first *Micractinium* green alga with an unusually thick wall and spines was observed in the Danube in August, 1968; it was subsequently publish-

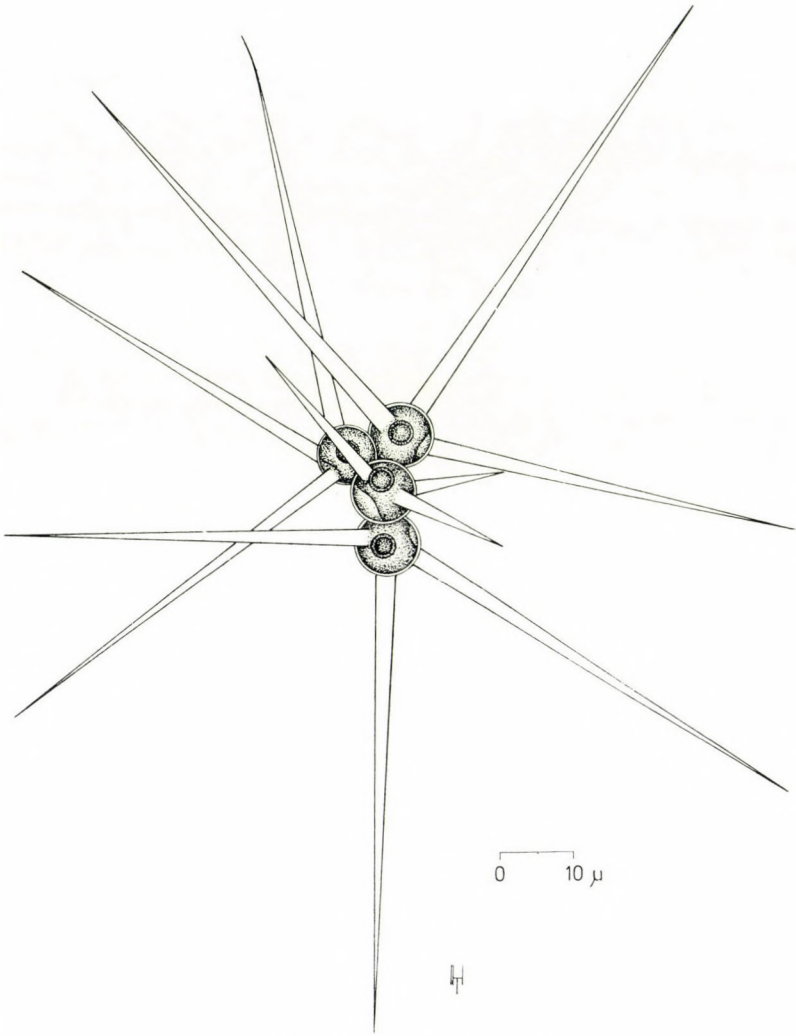


Fig. 1. Micractinium crassisetum Hortob.

ed as *Micractinium crassisetum* Hortob., in 1973 (p. 123). Cell dimensions 5.5—6.5 μ, length of spines 24.7—33.8 μ, basal breadth of spines 1.7—2.6 μ. *M. crassisetum* is well-distinguishable from the concurrent *M. pusillum*.

My recent observations complemented the original description. Diameter of cell 5.5—9 μ, length of the unusually thick-walled, sharply pointed spines 24.7—60 μ, width at base 1.7—2.8 μ. Cells globose, occasionally slightly compressed, elongated. Coenobia 2- or 4-celled, rarely 8 of cells. The most common form of occurrence is in groups of four (Fig. 1). — July—September.

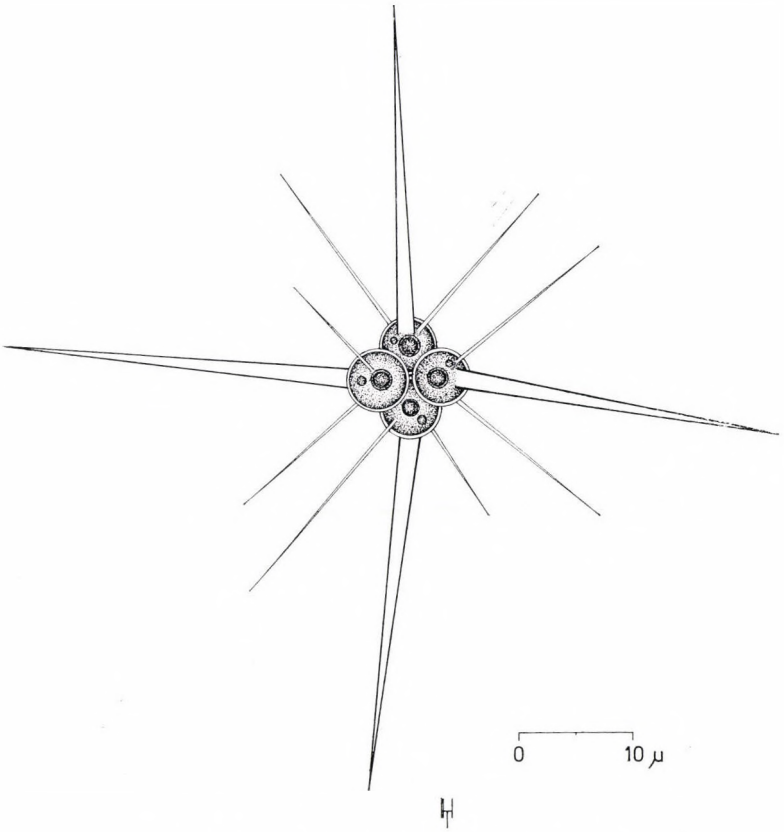


Fig. 2. Micractinium strigoniense Hortob. n. sp.

In the Danube samples collected in 1972—73. I found two further thick-spined *Micractinium* species. The three taxa show a good evolutionary series. They exemplify that the appearance of thick-spines is interpretable as parallel morphoses.

Micractinium strigoniense Hortob. n. sp.
Fig. 2

Coenobia 4-celled, diameter 5—5.5 μ. Cell-wall smooth. Cells not arranged in a plane. Each cell emitting a thick-walled, rigid, straight, sharply pointed spine with an intern cavity, length 30—33 μ. Beside each spine a thin-walled, rigid, straight, spharply pointed spine on both sides, length 16—19 μ. Basal breadth of long and thick spines 1.6—1.8 μ, that of the shorter spines 0.3—0.4 μ. Chloroplasts parietal, filling in cell, with a large pyrenoid. Propagation by auto-spores. In May, 1972: rare.

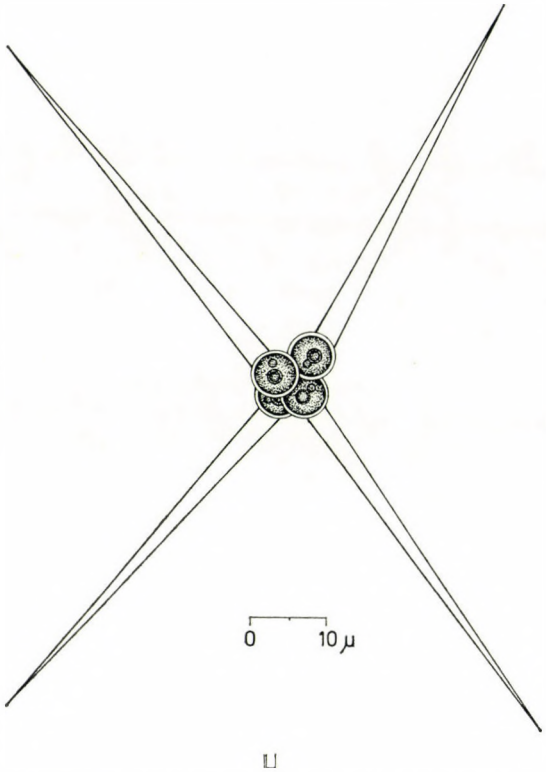


Fig. 3. Micractinium conococcoides Hortob. n. sp.

A close ally of *M. crassisetum* Hortob., but clearly distinguishable from it by its single thick spine and the shorter spines, one on each side of the former. It displays characteristics of *M. pusillum* Fresen and of *M. crassisetum* Hortob., with their thin and thick spines, respectively.

Micrantinium conococcoides Hortob. n. sp.
Fig. 3

The third thick-spined *Micractinium* with a considerable basal breadth is the simplest one, morphologically. Coenobia 4-celled, cells not arranged in a plane, smooth-walled, diameter 6—7 μ, sometimes slightly compressed. Each cell bearing only one thick-walled, straight, rigid, sharply pointed, hollow spinei length 47—51 μ, breadth of base 2.5—3 μ. Chloroplast parietal, filling in cell, with a well-discernible pyrenoid.

In July, 1973: rare.

It is closely related to *M. crassisetum* Hortob., but sharply differs from it, by having only a single spine on each cell.

It strikingly resembles *Conococcus elongatus* Carter. In this latter species each cell bears one broad-based spine, but the cells are arranged in a plane, while the specimens from the Danube have their cells arranged as characteristic of Micractinium, i.e. in an agglomeration.

DIAGNOSES

Micractinium strigoniense Hortob. n. sp.

Cellulae 5—5.5 μ diam., quaternae dispositae, in unaquaque earum spinae singulae, rigidae, rectae, crasse tunicatae, interne cavae, mucronatae, 30—33 μ longae, subtus 1.6—1.8 μ latae, ultro spinae binae tenuiter tunicatae, spinat singulas in medium accipientes, rigidae, mucronatae, cavae, 16-19 μ longae, ad basin 0.3—0.4 μ latae, chloroplastis parietalis pyrenoida conspicua. Propagatio per autosporas. Duna, 1973, V. — Raro.

Micractinium conococcoides Hortob. n. sp.

Coenobia 4-cellularia, e cellulis 6—7 μ diam. composita. In unaquaque cellula spinae singulae, crasse tunicatae, rigidae, rectae, mucronatae, cavae, 47—51 μ longae, ad basin 2.5—3 μ crassae. Chloroplastis parietalis. Pyrenoida conspicua. Duna, 1973. VII. — Raro

REFERENCES

HORTOBÁGYI T. (1973): Neue Chlorococcales aus den Absetz- und Grundwasseranreicherungsbecken der Budapester Wasserwerke. — Acta Bot. Acad. Sc. Hungaricae. Budapest, **18,** 119—130.

PHILIPOSE, M. T. (1967): Chlorococcales. — Indian Council of Agricultural Research, New Delhi, 1—365.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (3—4), pp. 367—372 (1976)

CHANGES IN THE PEROXIDASE ENZYME AND IN ITS ABILITY TO HYDROXYLATE UNDER THE EFFECT OF ACTINOMYCIN D AND CHLORAMPHENICOL IN SEEDLING BEAN PLANTS

By

M. M. HORVÁTH and J. NEMCSÓK

BIOCHEMICAL AND GENETICAL RESEARCH TEAM, JÓZSEF ATTILA UNIVERSITY, SZEGED (HUNGARY)

(Received June 7, 1974)

Recently the investigation of the effect mechanism of peroxidase and its part played in hydroxylating processes have come to the forefront. It is timely to examine the behaviour of compounds suitable for a complete inhibition at various points in the course of protein synthesis in relation to the quantity of peroxidase and to its ability to hydroxylate.

It can be inferred from present experiments that the inhibitors used (actinomycin D and chloramphenicol) are suitable to inhibit the activity and hydroxylating ability of the peroxidase enzyme.

Material and method

We carried out our experiments with seedlings of white pearl beans. They were germinated at 23°C in Petri dishes on filter paper in a thermostat for 3 days. When the rootlet was 1—1.5 cm long, it was placed in water culture. They were put in semi-conditioned circumstances, in tap-water lighted by 7000 lux (HORVÁTH—LASZTITY 1965). The age of our experimental plants was between 4 and 20 days. The measurement of the peroxidase enzyme was carried out as a function of time, according to the age of the plant, from the shoot and from the root, on the basis of the method elaborated by SOLYMOSY—FARKAS in 1963.

Parallel with the enzyme activity measurements, we also applied inhibitors and, on the one hand, examined their effect mechanism on the enzyme, and, on the other hand, studied their role and position at hydroxylation. The inhibitors used and their concentration were: 2 mg/ml chloramphenicol, and 2 mg/ml actinomycin D.

We placed our 7-day-old plants bearing two foliage leaves in boiling glasses into the inhibiting solutions, while the controls were also put in boiling glasses into tap-water, so that the treated and the control plants could be under identical conditions. Another one of our inhibiting experiment was to cut off the shoots of the plants and to put the shoots into the inhibiting solution, and in the tap-water; the roots were also placed into the inhibiting solution and in tap-water, respectively. Then we measured the activity of peroxidase in the function of treatment time; after a treatment of 24 hours, 48 hours and 9 days, we homogenized 2 g of each shoot and root of the treated and control plants, respectively, in 6 pH phosphate buffer, then incubated them at 25 ml end volume, with antranilic acid solution of 10 mMole concentration. We carried out incubation also with the other inhibitors, and also with horse radish peroxidase produced by us. The time of incubation was 24 hours. Before that, the incubation was tried also as a function of time (from 16 to 24 hours).

After incubation the system was stopped first by chloroform and then, to facilitate filtering, by 10% TCA. After stoppage, system was rinsed three times with ether. After evaporation, it was made run for two hours in 95 : 5 mixture of chloroform and acetic acid on kieselguhr plates prepared in advance, by adding drops at a time. Then the plates were developed by the Van Urk reagent. For one day after development, the plates were left to dry and then evaluated. Evaluation took place on the basis of Rf values (SIMON—MATKOVICS—M. HORVÁTH 1970).

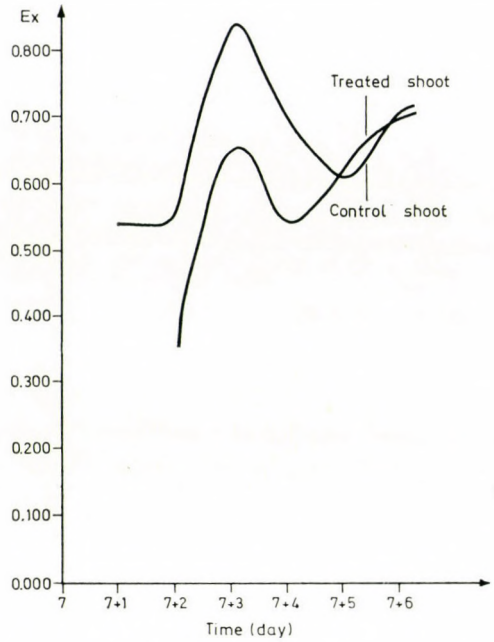


Fig. 1. The extinction curve as a function of time of the peroxidase activity in the 7-day-old bean seedling treated with actinomycin, and in the control seedling

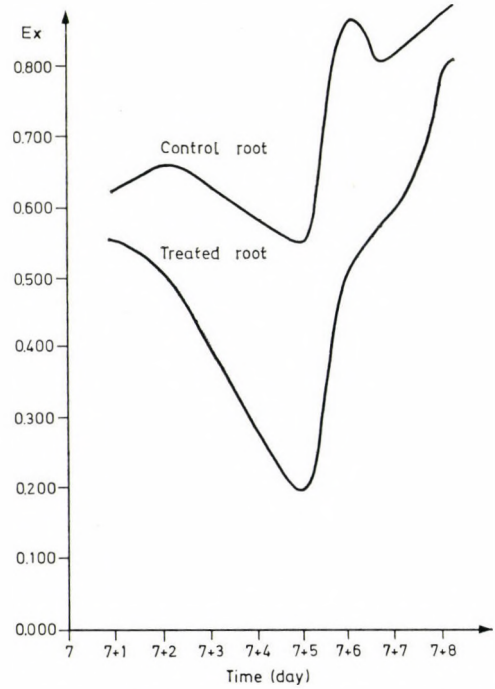


Fig. 2. The extinction curve as a function of time of the peroxidase activity in the 7-day-old bean root treated with actinomycin, and in the control root

Evaluation of the results

In the case of treatment with actinomycin D and chloramphenicol, the peroxidase enzyme activity of both the shoot and the root decreases to a considerable extent, owing to the effect of the treatment.

In Figs 1 and 2, the effect of actinomycin D, while in Figs 3 and 4 that of chloramphenicol on shoots and roots are illustrated, related in all four cases to that of the control.

Fig. 5 demonstrates the changes in the bean seedling and the activity of peroxydase enzyme as a function of time.

For the roots, the extinction in the enzyme activity is the greatest in the case of treatment with actinomycin D after a five-day treatment and for the shoots after a 2-day treatment. The effect of chloramphenicol had the conspicuously lowest value after a 4-day treatment, both in the shoots and in the roots. In this case the effect of actinomycin D results in the linking of the RNA polimerase being inhibited.

In the course of our experiments we found that when the shoot, the root, and the rooted plant had been previously treated and then incubated with anthranilic acid, the quality of the hydroxy derivatives was parallel with the

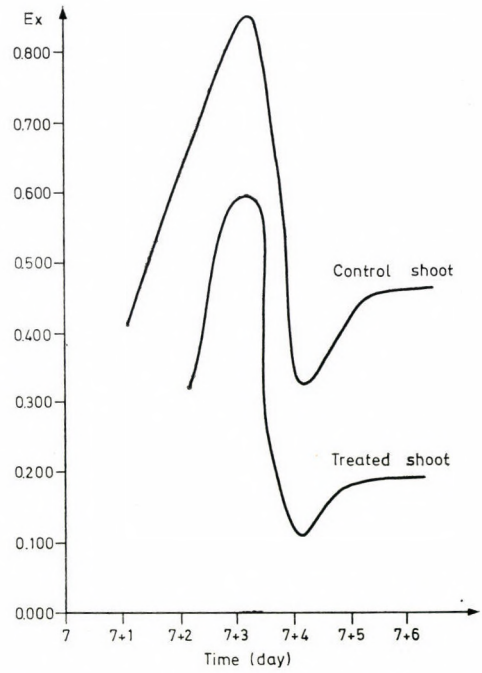


Fig. 3. The extinction curve as a function of time of the peroxidase activity in the 7-day-old bean shoot, and in the control shoot

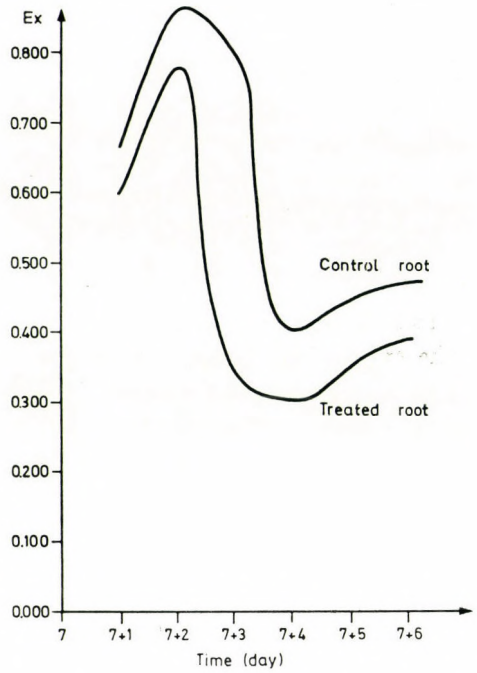


Fig. 4. The extinction curve as a function of time of the peroxidase activity in the 7-day-old bean root, and in the control root

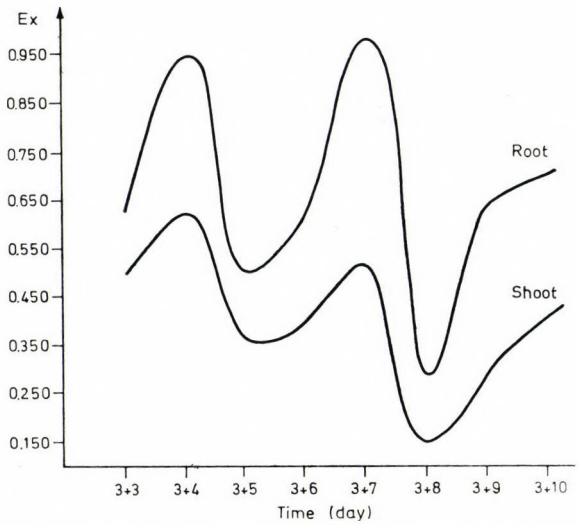


Fig. 5. Changes in the peroxidase enzyme as a function of age in the bean seedling

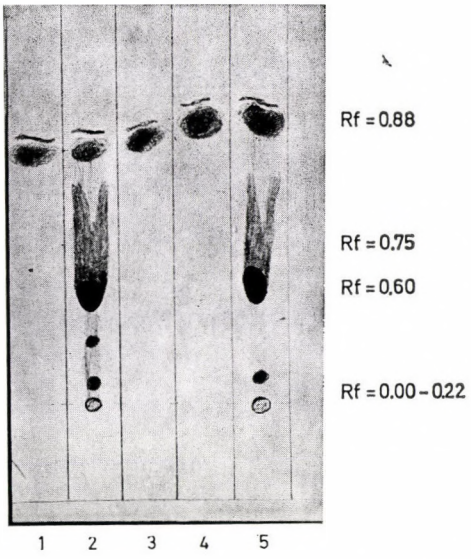


Fig. 6. The shoot and root of a 7-day-old bean seedling treated with actinomycin D for 24 hours, followed by a 24-hour incubation with antranilic acid, and its controls. 1 Treated shoot (anthranilic acid); 2 Control shoot (anthranilic acid 3-OH, 4-OH, 5- and 6-OH antranilic acid); 3 Treated root (anthranilic acid); 4 Treated root (anthranilic acid); 5 Control root (anthranilic acid, 3-OH, 5- and 6-OH anthranilic acid)

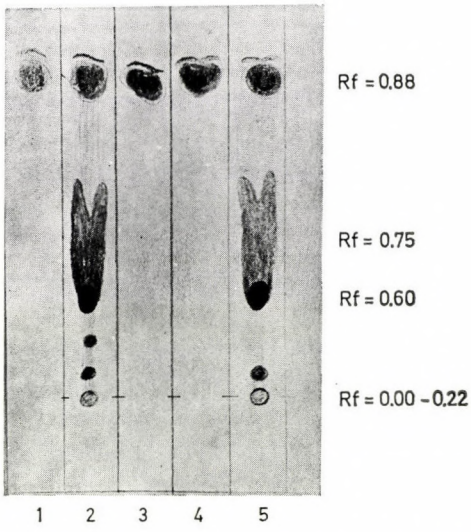


Fig. 7. The shoot and the root of a 7-day old bean seedling, followed by a 24-hour incubation with anthranilic acid, and its controls. 1 Treated shoot (antranilic acid); 2 Control shoot (antranilic acid, 3-OH, 4-OH, 5- and 6-OH antranilic acid); 3 Treated root (antranilic acid); 4 Treated root (antranilic acid); 5 Control root (antranilic acid, 3-OH, 5- and 6-OH antranilic acid)

activity of the peroxidase enzyme, and with the quantity of the enzyme Actinomycin D and chloramphenicol inhibited the occurence of all hydroxy derivatives both in the roots and in the shoots, in comparison with the control. This was to be expected, since the two inhibitors effect the most important synthesis processes, and therefore no hydroxy derivatives could be produced.

In the chromatograms presented here (Figs 6 and 7), it can be seen that the production of the hydroxy derivatives in all treated shoots and roots became extinct, in contrast to the case of the controls.

Our experiments allow the statement that the inhibitors used by us are suitable for the inhibition of activity and hydroxilating ability of peroxidase enzyme.

REFERENCES

LASZTITY, D.—HORVÁTH, M. (1965): Changes of Pigment in Barley Leaves. Acta Agr. Acad. Sci. Hung. **14**, 321—326.

SIMON, M.—MATKOVICS, B.—HORVÁTH, M. (1970): Biokémiai Vándorgyűlés Sopron, *II.* kötet 36. előadás. Növényi gyökerek aromás hidroxiláló képességének vizsgálata (Biochemical itinerary congress, Sopron, Volume *II*, Lecture No. 36: Examination of the aromatic hidroxylating ability in plant roots).

SOLYMOSY, F.—FARKAS, G. L. (1963): Metabolic caracteristics at the enzymatic level of Tobacco tissues exhibiting localized acquired resistance to virol infection. Virology, **21**, 210—221.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (3—4), pp. 373—379 (1976)

SOIL ALGAL GROWTH TYPES AS EDAPHIC ADAPTATION IN HUNGARIAN FOREST AND GRASS STEPPE ECOSYSTEMS

By

Zs. P. Komáromy

(Received October 11, 1976)

It was established that the algal synusia of forest ecosystems are of the *Chlorophyta* type, whereas the grass steppe ecosystems are algologically of the *Cyanophyta* type. A classification of soil algae has been made by the soil types, with special regard to soil texture. Six growth types were elaborated, of which five are fundamental and one is divided into two subtypes: they are of the dispersal (1), stratose (2), microcoleus (3.1), ramose (3.2), mucose (4) and glutinose (5) type.

The "structure" of ecosystems — species composition, their pattern, relations of species combinations, the growth type, life-forms, diversity of species etc. — reflects the ecological conditions in which they exist.

Most of the ecological papers discussing soil algae investigate the species composition from a taxonomical viewpoint. Others describe habitats in which the algal "communities" occur (e.g. Friedmann 1971, Lynn and Brock 1969, Cameron 1972). Some of the researchers attempt to recognise other relations of soil algal synusia (e.g. Shtina and Hollerbach 1976, Alexakhina 1971, Jegorova and Alexakhina 1974). Since certain terms have introduced in ecology (Odum 1959, Margalef 1963), it seems appropriate to interpret and use them also in algal ecology. As the basis of information exchange is a unified system of terms, this is an important matter.

When Shtina and Hollerbach (1976) devised their algological life-form system, it was founded on Schmithüzen's and Siribrjakova's life-form conception, However, Fekete and Szujkó-Lacza (1970, 1971) and Szujkó-Lacza and Fekete (1972) discussed in their series of papers, the problems of life-form conceptions and they defined the term life-form in agreement with Raunkiaer's basic concepcion. Accordingly, the term life-form should be distinguished from growth type also in algology. Life-form is a characteristic of adaptation to unfavorable seasons, while the growth type is a characteristic of taxonomic or edaphic adaptation during the growth period.

In the present paper, the growth types of soil algae are elaborated according to the structure of soil types, as a sequence to the study of species composition of the Hungarian forest and grass steppe ecosystems from the viewpoint of algology.

Material and methods

Different soil types were investigated from forest and grass steppe ecosystems in Hungary. The soil samples were taken from 500×500 cm plots divided into 25 (each 100×100 cm^2) quadrats; 25 soil samples were collected per soil types in each case.

Table 1

*Examined soil types and their localities characterized by vascular plant communities**

Localities	Vascular plant communities	Soil type	Soil structure
Mts. Mátra	*Deschampsio-Luzulo-Fagetum*	acidic, nonpodzolized brown forest soil	granular (gruel), diam. of soil particles 3—1 mm
Mts. Mátra	*Mercuriali-Tilietum*	mull-ranker	granular (gruel)
Mts. Mátra	*Melitti-Fagetum*	Ramann-type brown earth	granular (hazelnut), diam. of soil particles 5—3 mm
Hortobágy National Park	*Artemisio-Festucetum pseudovinae*	salt-affected soil (meadow solonetz)	columned, diam. of soil particles 50 mm
Hortobágy National Park	*Camphorosmetum*	salt-affected soil (solonetz with solod)	powdery, diam. of soil particles 0.5 mm

* The examinations and exact enumeration of soil types were given by KOVÁCS (1975) and SZABOLCS (1965).

To our knowledge, the water regime (quantity and quality of the soil moisture, water-holding capacity and permeability) and air regime of the soil depend on its structure (CSAPÓ 1958). When the examined soil types are grouped by structure, three groups can be distinguished (gruel, hazelnut and powdery).

The soil samples originating from forest soils were kept in culture, illuminated by light tubes (4000 lux, for six hours per day). The solonetz samples could be examined microscopically after sampling. The data of these samples offered the basic material of the analysis.

Species composition of soil types with respect to ecosystems

The first step in the analysis of soil algal synusia is to determine the species composition. The number of species and their taxonomic distribution are different in forest and grass steppe ecosystems (Fig. 1). In a previous paper (KOMÁROMY 1975), the algological characterization and quantitative examination of forest soils have already been enumerated and it has been underlined that the soils of forest ecosystems are characterized by *Chlorophyta* and *Xanthophyta* species (e.g. *Chlamydomonas, Chlorococcum, Botrydiopsis, Monodus, Vischeria* etc.).

It was found in the course of this work that algal cells occur usually sporadically in forest soils. Most of the samples had a long cultivation time (six or ten weeks), and some of them were negative. It was established that there are two or three species which played an important role in species composition (KOMÁROMY 1969). The soil types of forests differ from each other significantly and these differences are based on physical and chemical soil caracteristics (KOMÁROMY 1975).

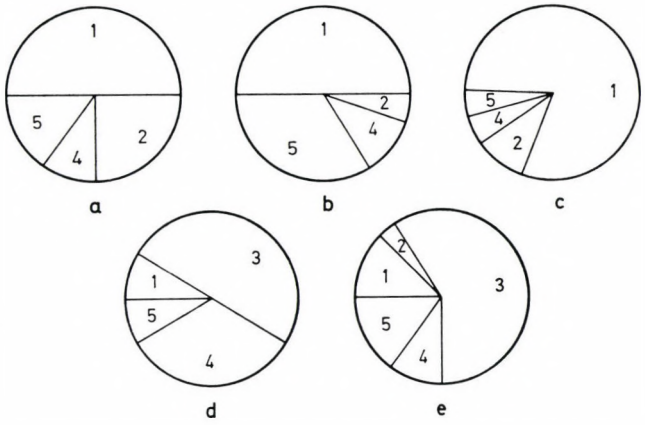


Fig. 1. The taxonomic proportion of the species in different forest and grass steppe soils. 1 — acidic nonpodzolized brown forest soil; 2 — mull-ranker; 3 — RAMANN-type brown earth; 4—5 — salt-affected soils (solonetz)

The *Chlorophyta-Xanthophyta* combination of soil algal synusia is characteristic of the European forest zone (SHTINA 1961, ALEXAKHINA 1971, JEGOROVA and ALEXAKHINA 1974, ROSA 1962).

The salt-affected soil types (e.g. examined solonetz) are in contrast to forest soils, of the *Cyanophyta* type, similarly to desert ecosystems.

The salt-affected soils were analysed by sample series originating from different localities in the Hortobágy National Park. The most frequent species were *Phormidium, Lyngbya, Nostoc, Microcoleus, Tolypothrix* and *Calothrix. Chlorhormidium crenulatum* (Kütz.) Kom. was abundant in some localities.

The soil samples could be examined microscopically directly after sampling, because the bare surface of soil was everywhere covered with algae. No essential difference was expected between the species composition of different localities in the case of samples originating from "szik" plots, but still some differences appeared between *Festucetum, Camphorosmetum* and "szik" plots.

An attempt to group soil algae by their growth type with special regard to soil texture

The species composition of soil algal synusia reflects also the edaphic conditions. These conditions consist of several effects, thus their examinations also gave several new aspects. One of them is soil texture (as a physical characteristic). The top layer of soils, as a substrate of synusia, is diverse by its different texture and structure, because different algal species can settle on it. Accordingly, the soil algal species may, independently also of their

Table 2

Joint occurrence of soil characters and algal growth types

Soil structure	Growth type	Examples
Granular (hazelnut) (5—3 mm ∅)	dispersal	*Chlorococcum humicolum* (Näg.) Rabenh. *Botrydiopsis minor* (Schmidle) Chod. *Monodus subterranea* Petersen *Vischeria stellata* (Chod.) Pasch.
Granular (gruel) (3—1 mm ∅)	stratose	*Chlorhormidium flaccidum* (Kütz.) Fott *Chlorhormidium dissectum* (Kütz.) Kom. *Chlorhormidium crenulatum* (Kütz.) Kom. *Stichococcus bacillaris* Näg. *Heterothrix exilis* Pasch. *Tribonema minus* (Wille) Hazen
Granular (gruel)	glutinose	*Hantzschia amphyoxis* (Ehr.) Grun. *Navicula mutica* Kütz. *Pinnularia borealis* Ehr.
Powdery (0.5 mm ∅)	microcoleus	*Microcoleus lacustris* (Rabenh.) Farl. *Microcoleus sociatus* W. et West. *Phormidium foveolarum* (Mont.) Gom. *Phormidium molle* (Kütz.) Gom. *Phormidium paulsenianum* Petersen
Columned (50 mm ∅)	ramose (tolypothrix)	*Tolypothrix tenuis* Kütz.
Columned (50 mm ∅)	mucose	*Nostoc commune* Vauch. *Nostoc microscopicum* Carm.

taxonomical positions, be divided into certain basic groups. When the basic groups are marked by serial numbers, the system can be widened at will.

1. The coccoid green and yellow-green algae, existing more or less dispersally among the soil particles, may be drawn together into a common group. The soil particles form small "niches" in which the algal cells have enough light and moisture to grow and multiply (Fig. 2a). This growth type occurs most frequently in soil types of a loose and granular texture (Table 2).

2. The filamentous green and yellow-green algae form, like the moss protonema, a dense coat on the soil surface. The proper designation of this type should be stratose, because the algal coat has no immediate connections with the top of the soil. The filaments retain rain water and numerous unicellular microorganisms occur in it. This growth type was found on acidic, nonpodzolized brown forest soil, on the bare soil of clearings and also on salt-affected soil (Fig. 2b).

3. The next group, called crust formation, may be subdivided into two parts:

3.1 One subgroup comprises the filamentous blue-green algae (e.g. *Phormidium, Lyngbya, Microcoleus* etc.) which, by their active motion, thoroughly interwave the soil surface so that the algal filaments are in close

connection with the soil particles. This so-called microcoleus type was observed on "szik" spots, on heavily tread paths, and on other places where the soil surface is very solid (Fig. 2c).

3.2 The ramose type (or tolypothrix type) forms the second subgroup; it was consistently found on half-closed *Festuca* grassland, on meadow solonetz. The red-brown filaments of *Tolypothrix tenuis* Kg. are covering the unoccupied places among *Festuca pseudovina* clumps. The branches of the filaments climb onto the soil surface, because they have positive phototropism, while other segments of filaments creep among the soil particles (Fig. 2d).

4. Some algal species (e.g. *Nostoc commune, Gloeocapsa arenaria, Chroococcus* minor and some terricolous *Chlamydomonas* species) with a slimy extracellular mucilage may be relegated to a common group, because they stick to the soil surface by mucilage. This group, called mucose type (Fig. 2e), is a characteristic constituent of the salt pastures in Hungary. The blackish-green mucilaginous thalli are the "birthplace" of edaphon on the grass steppe: numerous unicellular algae, the cysts of minute animals, the spores of molds etc. occurred inside the mucilage.

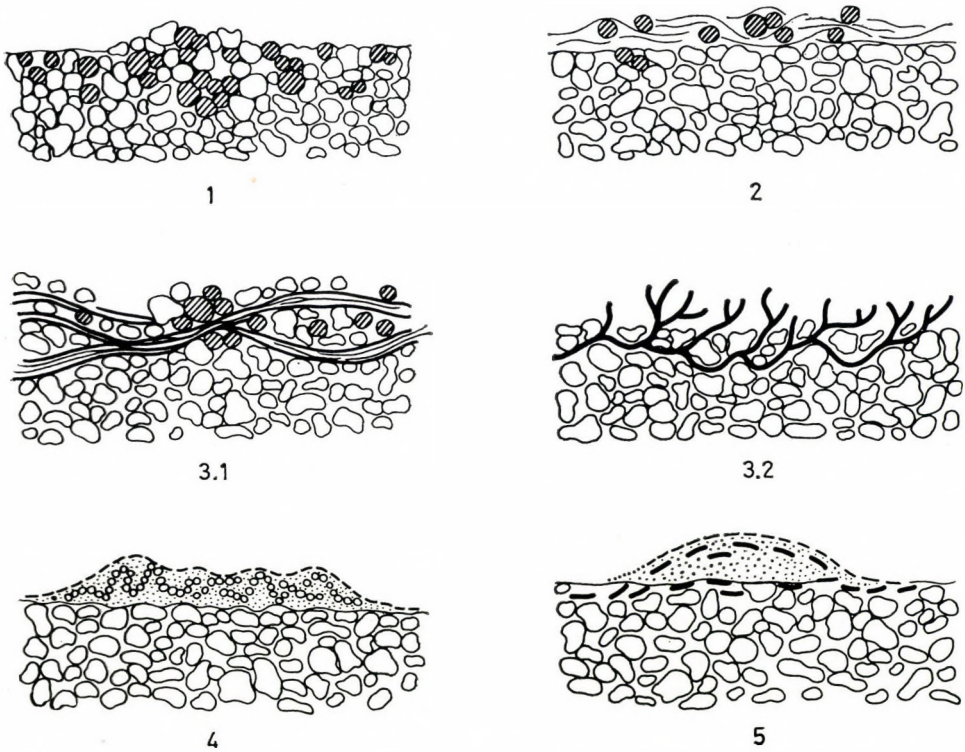


Fig. 2. Growth types of soil algae. 1. dispersal growth type; 2. stratose growth type; 3.1 microcoleus growth type; 3.2 ramose growth type; 4. mucose growth type; 5. glutinose growth type

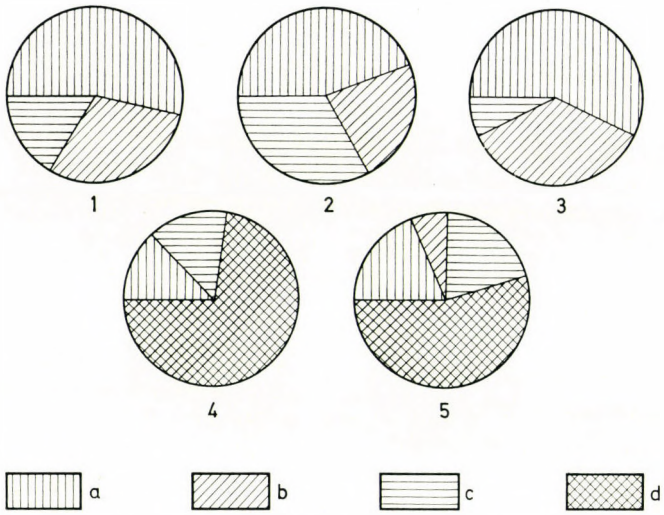


Fig. 3. The proportion of the algal species by growth types in different ecosystems. a—c forest ecosystems, a — acidic nonpodzolized brown forest soil; b — mull-ranker; c — RAMANN-type brown earth; d—e grass steppe ecosystems, salt-affected soils (solonetz). 1 dispersal; 2 stratose; 3 crust formation (microcoleus and ramose growth types); 4 mucose; 5 glutinose growth type

5. The last group may comprise the terricolous diatoms. They have extracellular mucilage and they can move. The so-called glutinose type of growth was well observable on the surface of agar-agar cultures. According to my observations, the diatoms live in the mucilage of other algal species (e.g. *Nostoc*), or among filamentous algae. Another place which the diatoms prefer is the permanently wet soil surface. Despite the fact that one cannot satisfactorily observe the glutinose type in the field, it should be distinguished from other growth types because the presence of diatoms is characteristic of certain soil types (Fig. 2).

Summary

The soil type with a loosely hazelnut structure (e.g. brown earth) is associated with the dominance of dispersal growth type; the mull-ranker and acidic, nonpodzolized brown forest soil of smaller particles (gruel structure) and with a high humus and wet content bear this dispersal, stratose or dispersal-stratose growth type; the powdery soil structure (solonetz with solod) is favourable to crust formations (microcoleus and tolypothrix type). The diatoms were usually associated with a permanently high water content. Apparently, the other edaphic effects are not important for them (Fig. 3).

ACKNOWLEDGEMENTS

Thanks are due to Dr. J. SZUJKÓ-LACZA and Dr. G. FEKETE, for their advice given in the course of my work.

REFERENCES

ALEXAKHINA, T. I. (1971): The peculiarities of soil algae flora in different types of forests. (in russian) Bot. Zhurn. **56,** 1658—1669.

CAMERON, R. E. (1972): A comparison of soil microbial ecosystems in hot, cold and polar desert regions. — In: Ecophysiological foundations of ecosystems productivity in arid zone. Leningrad, Nauka.

CSAPÓ, M. J. (1958): Talajtan (Soil science), Bukarest, 646 pp.

FEKETE, G.—SZUJKÓ-LACZA, J. (1970): A survey of the plant life-form systems and the respective research approaches. II. Ann. Hist.-nat. Mus. Nat. Hung. **62,** 115—127.

FEKETE, G.—SZUJKÓ-LACZA, J. (1971): A survey of the plant life-form systems and the respective research approaches. III. Ann. Hist.-nat. Mus. Nat. Hung. **63,** 37—50.

FRIEDMANN, E. I. (1971): Light and scanning electron microscopy on the endolithic desert algal habitat. — Phycologia, **10,** 411—428.

JEGOROVA, S. V.—ALEXAKHINA, T. I. (1974): Mikroflora i al'goflora pochv v nekotorykh fitotsenozakh Tellermanovskogo opytnogo lesnichestva (The soil microflora and algal flora of some phytocenosis in a forest at Tellermansko). Ekologiya, **4,** 20—26.

KOMÁROMY, Zs. P. (1969): Algological investigations on Hungarian forest soils. — Acta Bot. Acad. Sci. Hung. **15,** 291—297.

KOMÁROMY, Zs. P. (1975): Comparative algological studies in some soil types of Mátra Mountains. — Acta Bot. Acad. Sci. Hung. **21,** 289—304.

KOVÁCS, M. (1975): Beziehung zwischen Vegetation und Boden. Akadémia Kiadó, Budapest, 365. pp.

LYNN, R.—BROCK, T. D. (1969): Notes on the ecology of a species of Zygogonium (Kütz.) in Yellowstone National Park. J. Phycol. **5,** 181—201.

MARGALEF, R. (1963): On certain unifying principles in ecology. Amer. Nat. **97,** 72—79.

ODUM, E. P. (1959): Fundamentals of ecology. Saunders, Philadelphia 546 pp.

ROSA, K. (1962): Microedaphon im degradierten Kieferbestand und in Töpfen auf tertiärem Sand in Nova Ves bei Ceské Budejovice. Acta Univ. Carolinae, Biologia suppl.

SHTINA, E. A. (1961): Zonality in the distribution of soil algal communities. 7th International Congress of Soil Scientist. Madison, Wisc. 1960, **2—3,** 630—634.

SHTINA, E. A.—HOLLERBACH, M. M. (1976): Ekologiya pochvennykh vodoroslej (Ecology of soil algae). Akad. Sci. Press "Nauka", Moscow, 142 pp.

SZABOLCS, I. (1965): Salt-affected soils in Hungary. — Agrokémia és Talajtan. **14,** Suppl. 275—290.

SZUJKÓ-LACZA, J.—FEKETE, G. (1972): A survey of the plant life-form systems and the respective researches. IV. Ann. Hist.-nat. Mus. Nat. Hung. **64,** 53—62.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (3—4), pp. 381—391 (1976)

ON THE PHOTOSYNTHESIS AND CHLOROPHYLL EFFICIENCY IN BENTHONIC COMMUNITIES DOMINATED BY VAUCHERIA DICHOTOMA AGH. IN LAKE VELENCE (HUNGARY)

By

GY. LAKATOS

DEPARTMENT OF ZOOLOGY AND ANTHROPOLOGY, L. KOSSUTH UNIVERSITY, DEBRECEN

(Received September 22, 1976)

In addition to the knowledge of the chlorophyll concentration, the parameters which provide information on the physiological state of chlorophyll facilitate the exploration of the eutrophication of waters, and they also promote the clarification of the role played by planktonic and benthonic communities in aquatic ecosystems.

For the exploration of the specific characteristics of the benthic chlorophyll, photosynthesis examinations were made in the most characteristic and dominating benthic plant community of Lake Velence, viz. in the *Vaucheria* stand. Of the methods measuring photosynthesis, the dark and light bottle method was applied in our experiments, with O_2 indication.

On the basis of our investigations made in Lake Velence in the summer of 1973, the productivity parameters of the *Vaucheria dichotoma* mat are as follows:

$$P_{O_2} = 1.76 \text{ mg } O_2 \text{ Dm g}^{-1} \text{ h}^{-1}$$
$$P_C = 0.56 \text{ mg C Dm g}^{-1} \text{ h}^{-1}$$

Daily gross production value = 3.29 gC m^{-2} d^{-1}

For the benthic assimilation number of chlorophyll (AN) the value 0.24 was obtained, while the activity factor appeared as 0.01.

We can state that it is characteristic of the benthonic eutrophication that the sessile vegetation has a considerable quantity of biomass and, in connexion with this, a great quantity of chlorophyll, farther a low productivity, a small value of assimilation and a similarly small photosynthetic activity factor.

Introduction

Lately, eutrophication has become a worldwide evil incurred by civilization. Eutrophication is essentially a biological reaction ensuing an increase in nutriments, that is, a complex process of the changes in the increasing trophy of the aquatic ecosystem, which is accompanied by the increase of primary production capacity in it. The plant nutriments manifest themselves in two forms: phytoplankton consisting of microscopic algae that drift in open water and plants attached on some substrates, e.g. submerged aquatic plant stands, algal mats, biotecton, etc.

On the basis of the habitat and nature of the plant organisms fix, use and turn over energy, two forms of eutrophication can be distinguished viz. planktonic and benthonic eutrophication. In the case of the latter, an increase in the mass of sessile plants occurs as against the planktonic eutrophication which is caused by the free phytoplankton in the substrateless pelegiel.

The terminology used in our paper concerning assemblages living on the interface of water — solid substrate is as follows:

Organisms associated with the solid-liquid interface = *Benthon* (MORLIER 1951);

bottom-dwelling organisms = *Benthos* (HAECKEL 1891), *Phytobenthos*; *Zoobenthos*, etc.;

organisms adnate on solid surface = *Biotecton* (MARGALEF 1955), *Phytotecton*, *Zootecton*, etc.

In the shallow Hungarian waters, permitting plant life also at their bottom, phytobenthos may have an important role. Our paper deals with the production data of *Vaucheria dichotoma*, one of the characteristic bottom-dwelling plants of Lake Velence.

The separation of eutrophication into planktonic and benthonic ones (ANGER 1975, LAKATOS 1974) implies the problem of relationship and differences between planktonic and benthonic chlorophyll.

For the clarification of the specific characteristics of benthonic chlorophyll, photosynthetic examinations were made with regard to *Vaucheria dichotoma* the most characteristic and wide-spread benthic plant of Lake Velence.

Although several authors discuss the filiform alga *Vaucheria* (NIENNIUS and SIMONS 1972; POLDERMAN 1974; SIMONS 1974, 1975; SIMONS and VROMAN 1973, etc.), mainly taxonomical and cenological works are known from literature in contrast with investigations under discussion.

On the basis of recent information, the eutrophication of the aquatic ecosystems can be approached numerically through the intensity of plant life in the water. For this, the determination of the quantity of plants living in water, or a measuring of the intensity of primary production is to be made. For the estimation of the aquatic primary organic matter, the most important parameter is the quantity of chlorophyll a per volume of water body per unit of solid bottom surface. Since the relationship between chlorophyll and photosynthesis is not constant, chlorophyll efficiency is to be determined in every case.

The measuring of all these is not simple in the case of benthonic plants.

Site of investigation, materials and methods

Lake Velence

One of the large saline lakes of Central Europe is Lake Velence, which lies at the foot of the Velence Range, in a young Old-Holocene depression. The surface of the Lake is 25.9 km^2, its length 10.5 km and its greatest width 3.3 km. Its average waterdepth is 1.2 m, its greatest depth 3 m, its water quantity 40 million m^3. The tributary area is 615 km^2. The extension of its open water is 16 km^2, the rest is occupied by reed. The zero point of the water level is 103.3 m above the Adriatic.

One of the special characteristics of the water of the lake, resulting from its "functional state of being without an outlet", is that it has a great salt concentration (1000—1500 mg/l), which has led to a peculiar salt-water living world. Therefore the lake is a hydrobiological rarity. Another one of its features is its great degree of mosaic state, its stretch of water is, multiply subdivided by islands of reed, veritable "walls of reed", into several water spaces, and the various "clearings" can intercommunicate only through the thick of the reeds; therefore areas of different water qualities may develop in the lake, Nearly 20% of the open water area of the Lake Velence is covered with seaweed (KISS, E., 1972). The dominant benthic plant of the lake is *Vaucheria dichotoma* Aghard (215 ha), and the submerged macrophyte *Myriophyllum spicatum* L. (35 ha). In addition, *Ceratophyllum demersum* L., *Chara* sp., as well as *Najas marina* L., *Utricularia vulgaris* L., *Potamogeton pectinatus* L. are worth mentioning. The biomass examinations and photosynthesis experiments of the *Vaucheria dichotoma* stand were made in the water area "Hosszútisztás" of Lake Velence.

Materials and methods

The most difficult tasks of hydrobiological methods are the collecting of the biotecton and benthic assemblages (FORSBERG 1959 WOOD 1969, etc.). From the tough, thick, filamentous algal vegetation no sample can be taken by any kind of sampling device controlled from above. So, the only solution that remained was to dive under water and to collect algae by hand, from areas exactly located. For this purpose, an iron-frame sized 50×50 cm was used; it was placed on the bottom of the lake "at random". From the material gathered in a plastic basin, the deposit was emptied into numbered tulle bags and transported into the laboratory. The fresh weight of the collected filamentous algal specimens was measured, then a certain quantity of it was preserved for dry matter determination. For photosynthesis examination bundles of the filamentose collected algae were made by white thread, to ensure their easy placing into and removal from WINKLER vessels.

The photosynthetic study of the benthic vegetation and the problem of methodology have been discussed by several authors.

Concerning the procedures measuring the photosynthetic activities of aquatic productive organisms, the dark and light bottle technique with oxygen indication was used in our work.

In the projecting and carrying out of the photosynthetic examination of *Vaucheria dichotoma*, the papers by MEYER et al. (1943) and by FELFÖLDY (1960) were considered.

A short description of the method applied is as follows:

a) *Vaucheria dichotoma* had in each case been collected during the afternoon of the preceding day; white threads bundles of about 400 mg weight have been secured and left in filtered water of the lake, at room temperature during one night in the dark.

b) The water sample removed from the site of examination was filtered by means of bundles membrane filters until it was free of algae, then the dissolved oxygen content of the water was reduced by vacuum pumping.

c) In two tubes closed by smoothed stoppers, oxygen was immediately separated with reagents (the nought point of the experiment). Then WINKLER bottles of known volume were filled with water with reduced oxygen, and one of the prepared bundles was placed. A few of the WINKLER bottles were covered with aluminium foil (dark bottle), while the rest remained light (light bottle).

d) "Relative examinations" were first made with the samples placed near the water surface, when we obtained information on the photosynthetic capacity of the various bundles (calibration run).

e) After measuring the relative photosynthetic capacity of the *Vaucheria* bundles, we measured the photosynthesis of the algal filaments in three depths of the lake (experimental run), and from the ratio of the two values, the apparent photosynthesis was expressed.

f) The photosynthetic examination of the algal bundles, exposed near the bottom, was made for the degree of chlorophyll efficiency; light and dark bottles were used.

g) After exposing, the modified version of the WINKLER method (FELFÖLDY 1974) was used for the determination of dissolved oxygen in the light and dark bottles:

$$\text{net photosynthesis} = \text{light bottle} - \text{nought point}$$

$$\text{gross photosynthesis} = \text{net photosynthesis} - \text{nought point} + \text{dark bottle}$$

$$\text{apparent photosynthesis} = 100 \cdot \frac{\text{experimental run}}{\text{calibration run}}$$

The oxygen quantity produced during one hour was expressed for the unit values of fresh weight, dry matter weight, ash-free dry matter weight, chlorophyll, nitrogen and phosphorus.

The determination of dry-matter was made, as usual, at 105°C, while that of the ash-free dry-matter weight at 600°C. The determination of chlorophyll was made on the basis of the methods published by LORENZEN 1967, IWAMURA et al. 1970.

The determination of total-N was made by the usual KJELDAHL method, after destruction and neutralization by concentrated solution of sulphuric acid through the destillation in boric acid of the ammonia originating from organic nitro-compounds. The essential point in the determination of the total P is that all the phosphorus forms should be transformed into orthophosphate by the destruction. With the dissolved orthophosphate ions, the molybdate sulphuric acid reagent produces a yellow complex which it reduced by the ascorbic acid solution, to result in a blue-colour complex; this undergoes photometry. Since the determination of N and P has taken place from the same sample, no selenic catalyzer was used which would disturb the measurement of phosphorus.

From the analytical measures obtained, characteristic parameters were calculated; the production of O_2 (mg O_2 Dm $g^{-1} h^{-1}$), fixed CO_2 and C (PQ = 1.2); we calculated the C value of the daily fixed coal and the C falling on one unit of surface (mg C m^{-2}); we determined the efficiency of the benthic chlorophyll (its assimilation number): the efficiency of chlorophylla = fixed mg C h^{-1}/1 mg chlorophylla (STRICKLAND 1960). The activity factor was calculated as assimilated C/biomass C.

Results

In Table 1, a few of the characteristic parameters of *Vaucheria dichotoma*, collected at "Hosszutisztás" of Lake Velence, are given together with the fresh weight per unit surface, and with the quantities of dry matter and chlorophyll a.

Table 1

Dry matter percentage (Dm%) of Vaucheria dichotoma, its fresh weight per 1 m^2 and the quantity of dry matter and of chlorophyll a; Hosszútisztás, August 9, 1973

Sample	Dm %	Wm gm^{-2}	Dm gm^{-2}	C_a gm^{-2}
1	14.37	4640	666.76	1.308
2	13.07	4920	643.04	1.044
3	13.05	6600	993.28	1.670
4	16.88	3760	634.68	0.995
Average	14.84	4928	734.44	1.254

Dm = dry matter
Wm = wet matter
C_a = Chlorophyll a concentration

On June 26, 1973, preliminary examinations were made for the clarification of certain methodological problems. An answer was obtained with respect to the duration of optimal exposition (3—4 hours), to the necessary size of the photosynthesizing *Vaucheria* bundle (0.250—0.800 mg WM).

The preliminary investigations were satisfactorily utilized in the depth experiments made on August 1, when the photosynthesis of the alga was examined at various depths. The results are summarized in the following table.

Sample	Calibration run	Experimental run		$\frac{\text{Experimental run}}{\text{Calibration run}} \cdot 100$
	mg O_2 Dm $g^{-1} h^{-1}$	Depth m	mgO_2Dm $g^{-1}h^{-1}$	
1.	1.48	0.1	1.32	89.2
2.	1.51	1.0	1.60	105.9
3.	1.38	2.0	1.96	142.0

On the basis of the results published by MEYER et al. (1943) and FELFÖLDY (1960), we calculated the apparent photosynthesis values. According to our examinations, these values are the most intensive in sunny weather, under a suitable transparency (SECCHI transparency about 160 cm), in the natural habitat of *Vaucheria dichotoma* where photosynthesis takes place, that is, at bottom of the water bed. Therefore, it can be stated that the benthic *Vauche-*

Table 2

I.

The measured photosynthesis values of Vaucheria dichotoma; Hosszútisztás, August 9, 1973

Sample light bottle	$n\Delta O_2$ mg bottle^{-1}	Wm mg	$b\Delta O_2$ mg Wm mg^{-1}	Dm mg
1	+0.0219	258.0	+0.0565	28.4
2	+0.0352	451.0	+0.0956	55.8
3	+0.0365	354.0	+0.0839	46.0
4	+0.0417	316.0	+0.0840	54.9
Average	0.0338	361.3	0.0800	46.7

$n\Delta O_2$ mg = experimental net photosynthesis, O_2 production/bottle
$b\Delta O_2$ mg = experimental gross photosynthesis, O_2 production/wet weight
Wm = wet matter
Dm = dry matter

Table 3

II.

The photosynthesis values of Vaucheria dichotoma, expressed in divers units; Hosszútisztás, August 9, 1973

No. of sample	Wm mg	mg O_2 · Wm $g^{-1} \cdot h^{-1}$	Dm mg	mg O_2 · Dm $g^{-1} \cdot h^{-1}$	Om mg	mg O_2 · Om $g^{-1} \cdot h^{-1}$
1	258.0	0.219	28.4	1.989	23.1	2.450
2	451.0	0.212	55.8	1.717	44.5	2.151
3	354.0	0.237	46.0	1.826	37.0	2.271
4	382.0	0.220	54.9	1.490	44.4	1.844
Average	361.3	0.222	46.27	1.756	37.2	2.179

Wm = wet matter
Dm = dry matter
Om = organic matter (ash free dry matter)
Depth of water = 220 cm
SECCHI disk transparency = 166 cm
Temperature of water surface = 22.5°C, bottom = 22.4°C
Windy, sunny weather

Table 4

III.

Photosynthesis values of Vaucheria dichotoma, in divers units; Hosszútisztás, August 9, 1973

No. of sample	C_a mg	mg $O_2 \cdot Ca$ $mg^{-1} h^{-1}$	N mg	mg $O_2 \cdot N$ $mg^{-1} h^{-1}$	P mg	mg $O_2 \cdot P$ $mg^{-1} h^{-1}$
1	0.0807	0.700	0.264	0.214	0.0153	3.693
2	0.1241	0.772	0.519	0.185	0.0301	3.183
3	0.0957	0.878	0.428	0.196	0.0248	3.387
4	0.0849	0.963	0.511	0.160	0.0296	2.760
Average	0.0990	0.828	0.482	0.189	0.0280	3.256

Ca = chlorophyll a content of sample
N = nitrogen content of sample
P = phosphorus content of sample

Chemical analysis results of *Vaucheria dichotoma*, given in percentage of dry matter content:

Dm% = 12.65 (expressed in fresh weight percentage)
Om% = 80.55
A % = 19.45
Ca % = 0.214
N % = 0.930
P % = 0.054

ria is a shade alga with very intensive inhibition of light oversaturation and that its photosynthetic apparatus is adjusted to the dim light of the bottom. On the basis of our depth experiments, all further measurements were made on the bottom of the centre of the Lake, in "Hosszutisztás".

Our data on the O_2 production of *Vaucheria dichotoma* and on the degree of efficiency of chlorophyll a are obtained from our examinations made on August 9, 1973. The results are given in Table 2.

We give the oxygen quantities produced by the plant (gross photosynthesis) in relation to various values in Tables 3 and 4. Despite the fact that, as a result of the relatively small number of samples, the results are rather similar inferences may be drawn only with due caution.

Discussion

On the "Hosszutisztás" of Lake Velence, the phytomass of the *Vaucheria* stand produced 736 g dry matter m^{-2} in 1973. *Vaucheria dichotoma* is a dense, powerful, gold-shining, filamentous alga of rough thread; it forms a tangled web at bottom and fully merges into its environment.

The average oxygen production of the *Vaucheria dichotoma* mat is 1.76 mg O_2 Dm g^{-1} h^{-1} (see Table 3). From this, with a value of Q = 1.2

(STRICKLAND 1960, WESTLAKE 1963), 1 g dry matter fixed 2.02 mg CO_2, or 0.56 mg C, per one hour. If the value related to one hour is multiplied by 8 — although according to WETZEL (1964) these kinds of conversions are debatable — the production of a whole day is obtainable, which in our case is 4.48 mg C Dm g^{-1} d^{-1}. From our data of measurements, we know the average dry matter weight of the *Vaucheria dichotoma* mat, thus we can calculate the daily gross production per one unit of surface area (with the reduction of the loss of respiration at night). For the *Vaucheria* mat, the daily gross production value is 3.29 gCm^{-2} daily gross production values measured by various authors are submitted as follows:

Author	Sites	Method	Result
BERMAN and POLLINGER (1924)	Lake Kinneret phytoplankton	O_2	3.6
BÖSZÖRMÉNYI et al. (1962)	Lake Balaton phytoplankton	C^{14}	0.171—0.408
EDWARDS and OWENS (1960)	River Ivel macrophyton	O_2	0.5—1.44
HUNDING (1973)	Lake Almonds microphytobenthos	O_2	0.105
LAKATOS (1976)	Lake Velence *Vaucheria* phytobenthos	O_2	3.29

On the basis of our measurements, the productivity of the *Vaucheria* mat is low (0.56 mgO Dmg^{-1} h^{-1}); the daily gross production of the masses of filamentous alga can approximate the values measured at the period algal bloom by BERMAN and POLLINGER (1974).

For the designation of chlorophyll efficiency, WILLSTÄTTER and STOLL (1918) suggested the assimilation number (Assimilationszahl). In our work, the assimilation number suggested by STRICKLAND (1960) was applied (fixed mg C h^{-1} mg chlorophyll a).

The knowledge of the chlorophyll efficiency, that is, the relationship between chlorophyll concentration and photosynthesis intensity, can be fruitfully used in the exploration of the eutrophication of a certain water body aquatic area — naturally in combination with other indices (for example, chlorophyll concentration, primary production, etc.). The assimilation number of the benthic filamentous algae of *Vaucheria dichotoma* in Lake Velence is AN = 0.26. The knowledge of the chlorophyll efficiency (qualitative side) supplements the value of chlorophyll concentration (quantitative side) well and from their product conclusions can be drawn with regard to the magnitude of the primary production as well:

$$P = C_{Ca} \cdot AN$$

where

P = primary production
C_{Ca} = chlorophyll a quantity per unit of volume or surface
AN = assimilation number.

Further, we know the *Vaucheria* mat dry matter content, which is 734 g Dm m^{-2}, and the average chlorophyll a content (0.214%), hence the quantity of chlorophyll a per unit of surface is 1.57 g chlorophyll a m^{-2}.

$$1.57 \text{ g} - \text{Ch a } m^{-2} \cdot 0.26 \text{ g C } g^{-1} \text{ Cha } h^{-1} = 0.408 \text{ g C } m^{-2}h^{-1} \times 8 =$$
$$= 3.264 \text{ gC } m^{-2} d^{-1}$$

The calculated daily gross production value of the *Vaucheria dichotoma* stand is 3.26 g C m^{-2} d^{-1}.

Since, on the basis of our present-day knowledge, the ratio between the chlorophyll content and the quantity of light assimilated per unit of time cannot be estimated with general validity, chlorophyll efficiency is to be determined from case to case. In the table below, planktonic and benthonic chlorophyll efficiency values are given as measured by various authors:

Author	Investigation site	AN
Caperon et al. (1971)	subtropical estuarium phytoplankton	7.2—14.5
Dokulil (1973)	Lake Fertő; phytoplankton among reeds	0.69—2.06
Dokulil (1973)	Lake Fertő; high pelagic phytoplankton	4.36—6.55
Felföldy (1961)	Balaton; layer *Diatoma* community (calculated)	0.44
Felföldy (1963)	Balaton; phytoplankton	1.2—2.9
Gessner (1949)	Wessling-See (average)	3
Lakatos (1975)	Nagyiván, Lake Darvas, phytobenthos	0.84
Odum et al. (1958)	Laguna Madre of Texas phytoplankton phytobenthos	3.8 0.5—0.9
Manning and Juday (1941)	Wisconsin lakes	2
Rytner (1956)	*Dunaliella* culture	3
Rytner and Yentsch (1957)	Seashore zone (average)	6
Szczepanska (1968)	Lake; Mikolayski biotecton (periphyton)	0.65
Lakatos (1976)	Lake Velence; *Vaucheria dichotoma* phytobenthos	0.26

From the results of the above table, and from the AN values given in the paper by ODUM et al. (1958), it seems that the efficiency of *Vaucheria* chlorophyll a measured by us is rather low. (An interesting ability of *Vaucheria* is that the plastides always wander towards the parts best illuminated within the filament; this wandering takes its course on the one hand along the longitudinal axis of the filament, but it can be noticed also in the cross-section of the filament: the filament acts as a cylinder lense, the plastides assemble in the point nearest the light and in that fartherst from it (personal communication, HAJDU).

On the basis of a comparison with literature data, we may state that (although the assimilation number may be influenced by several factors which cannot be left out of consideration) the chlorophyll efficiency of the benthic plants is always smaller than that of the planktonic plants. The difference in advantage to the latter can be explained by taking into consideration their place occupied in the water space, discussed in detail in the papers by ODUM and PINKERTON 1955, and ODUM and co-workers (1958).

With regard to the physiological state of chlorophyll, information can be obtained also from the photosynthetic activity factor, by use of the equation:

$$\text{activity factors} = \frac{\text{assimilated coal g } d^{-1}}{\text{biomass coal g}}$$

The activity factor for *Vaucheria dichotoma* is smaller than 0.01, which is more than ten times less than that given for phytoplankton (AHLGREN 1970. BERMAN and POLLINGER 1974; FINDENEGG 1965; JAVORNICZKY 1966; ODUM 1957, etc.). Several authors proved that, similarly to the assimilation number, a reversed proportionalitiy exists between the activity factor and the biomass (BERMAN and POLLINGHER 1974; GOLDMAN and co-workers 1968; RODHE 1958 etc.). The activity factor is an important ecological parameter which relates to the age and state of the ecosystem (ODUM 1957).

The considerable biomass of the sessile vegetation and in connexion with it, the great quantity of chlorophyll, as well as the low productivity, small assimilation number and photosynthetic activity factor, are characteristic of benthonic eutrophication.

On the basis of literary data and of our results of examinations, it can be stated that the benthic chlorophyll efficiency is smaller than the planktonic one, while at the same time the benthic chlorophyll may be a considerable quantity in the given aquatic area, and on the basis of the correlation which has been analysed it can be inferred that the benthic plants also play a considerable part in the matter and energy turnover of the aquatic ecosystem (HARGRAVE 1969, PIECZYNSKA and SZCZEPANSKA 1966, RICH and co-workers 1971, SCHINDLER and FREE 1973, STRASKRABA 1963, WETZEL 1964, etc.

In our opinion, the exploration of the degree of trophy of waters — that of their eutrophication — is to a great extent facilitated, and made more accurate together with information on chlorophyll concentration, by the parameters studied by us which make the elaboration of further details possible.

ACKNOWLEDGEMENTS

This study was made at the Research Institute for Water Resources Development, Budapest. I am indebted to Prof. L. FELFÖLDY and to Dr. L. HAJDU, for advice during the study. I should like to express my gratitude also for their valuable discussions and linguistic help.

REFERENCES

AHLGREN, G. (1970): Limnological studies of Lake Norviken, an eutrophicated Swedish lake. **2,** — Schweiz. Z. Hydrol. **32,** 354—396.

ANGER, K. (1975): On the influence of sewage pollution on inshore benthic communities in the South of Kiel Bay. Part **2,** Quantitative studies on community structure. — Helgol. wiss. Meeresunters. **27,** 408—438.

BERMAN, T.—POLLINGHER, U. (1974): Annual and seasonal variations of phytoplankton, chlorophyll, and photosynthesis in Lake Kinneret. — Limnol. Oceanogr. **19,** 31—54.

BÖSZÖRMÉNYI Z.—CSEH E.—FELFÖLDY L.—SZABÓ E. (1962): A Balatonban C^{14}-módszerrel végzett fotoszintézis mérés módszertani kérdésairől (On the methodological problems of measuring photosynthesis in Lake Balaton by means of C^{14} method) — Annal. Biol. Tihany **29,** 39—63.

CAPERON, J.—CATTEL, S. A.—KRASNICK, G. (1971): Phytoplankton kinetics in a subtropical estuary: eutrophication. — Limnol. Oceanogr. **16,** 599—607.

DOKULIL, M. (1973): Planktonic primary production within the Phragmites community of Lake Neusiedlersee (Austria). — Pol. Arch. Hydrobiol. **20,** 175—180.

EDWARDS, E. W.—OWENS, M. (1960): The effects of plants in river conditions I. Summer crops and estimates of net productivity of macrophytes in chalk stream. — J. Ecol. **48,** 151—160.

FELFÖLDY, L. J. (1960): Apparent photosynthesis of Potamogeton perfoliatus L. in different different depths of Lake Balaton. — Annal. Biol. Tihany **27,** 201—208.

FELFÖLDY, L. J. (1961): Effect of temperature on the photosynthesis of a natural diatom population. — Anal. Biol. Tihany **28,** 95—98.

FELFÖLDY L. J. (1963): A klorofill mérés módszertani és elvi kérdései balatoni eredményeinkkel kapcsolatban (Questions of methods and principles with regard to chlorophyll measurements on the basis of results in Lake Balaton) — Annal. Biol. Tihany **30,** 137—165.

FELFÖLDY, L. (1974): A biológiai vízminősítés (The biological qualification of water body). VIZDOK, Budapest, 1—242.

FINDENEGG, I. (1965): Relationship between standing crop and primary productivity. — Mem. Ist. Ital. Idrobiol. **18,** (suppl.) 271—289.

FORSBERG, C. (1959): Quantitative sampling of subaquatic vegetation. Oikos, **10,** 1959, p. 233—240.

GESSNER, F. (1949): Der Chlorophyllgehalt im See und seine photosynthetische Valenz als geophysikalisches Problem. — Schweiz. Z. Hydrol. **11,** 378—410.

GOLDMAN, C. R. (1968): Aquatic primary production. Amer. Zool. **8,** 31—42.

HAECKEL, E. (1891): Plankton-Studien. Jenaische Zeitschr. f. Naturw. **25,** 232—336.

HARGRAVE, B. T. (1969): Epibenthic algal production and community respiration in the sediments of Marion Lake. — J. Fish. Res. Bd. Canada **26,** 2003—2026.

HUNDING, C. (1973): Diel variation in oxygen production and uptake in a microbenthic littoral community of a nutrient-poor lake. — Oikos **24,** 352—360.

IWAMURA, T., NAGAI, H.—ICHIMURA, S. (1970): Improved methods for determining contests of chlorophyll, protein ribonucleic acid in planktonic populations. Int. Rew. Ges. Hydrobiol. **55,** 131—147.

JAVORNICKY, P. (1966): Measurements of production and turn-over of phytoplankton in four localities of Poland. — Ekol. Pol. Ser. A. **14,** 203—214.

KISS, E. Cs. (1972): The map of vegetation of Lake Velence is ready — Halászat **18,** 20—21 (In Hungarian only).

LAKATOS Gy. (1975): The benthonic—eutrophication and its actual problems in the Lake Velence — Manuscript. 118. pp. (In Hungarian only)

LAKATOS Gy. (1975): Observations on the chlorophyll efficiency in phytobenthos. — Presentation in Hydrobiologic Days at Tihany (in Hungarian Only)

LORENZEN, C. J. (1967): Determination of chlorophyll and pheopigments; Spectrophotometric equations. — Limnol. Oceanogr. **12,** 343—346.

MANNING, W. M.—JUDAY, R. E. (1941): The chlorophyll content and productivity of some lakes in northeastern Wisconsin. Trans. Wisc. Acad. Sci. **33,** 363—393.

MARGALEF, R. (1955): Los organismos indicadores en la limnologia. Biologia de las aguas continentales **12,** 300 p.

MEYER, B. S.—BELL, F. H.—THOMPSON, L. C.—CLAY, E. I (1943): Effect of depth of immersion on apparent photosynthesis in submersed vascular aquatics. — Ecology **24** 393—399.

NIENHUIS, P. H.—SIMONS, J. (1971): Vaucheria species and some other algae on a dutch salt marsh, with ecological notes in their periodicity. — Acta Bot. Neerl. **20,** 107—118.

ODUM, H. T (1957): Trophic structure and productivity of Silver Springs, Florida. — Ecol. Monogr. **27,** 55—112.

ODUM, H. T.—PINKERTON, R. C. (1955): Times speed regulation, the optimum efficiency for maximum power output in physical and biological systems. — Amer. Scient. **43,** 331—343.

PIECZYNSKA, E.—SZCZEPANSKA, W. (1966): Primary production in the littoral of several Masurian Lakes. — Verh. Int. Ver. Limnol. **16,** 372—379.

POLDERMAN, P. J. G. (1975): Some notes on the algal vegetation of two brackish polders on Texel (The Netherlands). — Hydrobiol. Bull. **9,** 23—34.

RICH, P. H.—WETZEL, R. G.—VAN THUY, N. (1971): Distribution, production and role of aquatic macrophytes in a southern Michigan marl lake. — Freshw. Biol. **1,** 3—21

RODHE, W. (1958): Primärproduktion und Seetypen. — Verh. Int. Ver. Limnol. **13,** 121—141.

RYTHER, J. H. (1956): The measurement of primary production. — Limnol. Oceanogr. **1.** 72—84.

RYTHER, J. H.—YÚNTSCH, C. S. (1957): The estimation of phytoplankton production in ocean from chlorophyll and light data. — Limnol. Oceanogr. **2,** 281—286.

SCHINDLER, D. W.—FEE, E. J. (1973): Diurnal variation of dissolved inorganic carbon and its use in estimating primary production and CO_2 invasion in lake 227. — J. Fish Res. Bd. Canada **30,** 1501—1510.

SIMONS, J. (1974): Vaucheria birostris n. sp. and some further remarks on the genus Vaucheria in the Netherlands. — Acta. Bot. Neerl. **23,** 399—413.

SIMONS, J. (1975): Vaucheria species from estuarine areas in the Netherlands. — Netherlands J. of Sea Res. **9,** 1—23.

SIMONS J.—VROMEN, M. (1973): Vaucheria species from the Dutch brackish inland ponds "De Putten". — Acta. Bot. Neerl. **22,** 177—192.

STRASKRABA, M. (1963): Shore of the littoral region in the productivity of two fishponds in Southern Bohemia. — Rospsravy Ceskoslovensko Akademia Véd Rade matematikych a prirodnich véd, **73,** 1—364

STRICKLAND, J. D. H. (1960): Mesuring the production of marine phytoplankton. — J. Fish. Res. Bd. Canada, Bull. **122,** 1—172.

SZCZEPANSKA, W. (1970): Periphyton of several lakes of the Mazurian Lakeland. Pol. Arch. Hydrobiol. **17,** 397—418.

WETZEL, R. G. (1964): A comparative study of the primary productivity of higher aquatic plants, periphyton and phytoplankton in large shallow lake. — Int. Rev. Ges. Hydrobiol. **49,** 1—64.

WILLSTÄTTER, R.—STOLL, A. (1918): Untersuchungen über die Assimilation der Kohlensäure Sieben Abh., Berlin, Springer, 1—448.

WOOD, D. R.—HARGRAVES, E. P. (1969): Comperative benthic plant ecology by SCUBA-monitored quadrats. Hydrobiologia **33,** 561—586.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (3—4), pp. 393—402 (1976)

AIR POLLUTION OF THE ECOSYSTEM AREA ON AN OAKWOOD AND THE NATURAL 3,4 BENZO-PYRENE CONTENT OF THE SOIL AND PLANT SAMPLES IN THE ECOSYSTEM*

By

F. MEDVE

INSTITUTE FOR HYGIENE AND EPIDEMIOLOGY, UNIVERSITY OF MEDICINE, DEBRECEN

(Received November 1, 1976)

The paper contains the data of a 3-years' examination of air pollution in a self-preserving ecosystem. The author measured the quantity of sedimentary and suspended particulate matter, sulphur dioxide, total sulphur, nitrogen oxide, and examined the natural 3,4-benzo-pyrene content of the soil and plant samples. The results can be considered as the data of the natural background.

Although a number of surveys of pollution in the environment have been made in Hungary, no examinations were carried out in closed areas allegedly relatively undisturbed up to the present time in areas which are far removed from both industrial and other inhabited regions.

Within the framework of the research work named "Sikfőkut Project (7)" we had the opportunity to carry out basic samplings in the area given in the title of our paper. With respect even to the future, it may prove very useful to compare the results obtained here — as a background — with those measured in the inhabited areas, or with those to be obtained later in similar samplings. This is the reason for the selection of such an area, which lies in the southern part of the beech-land region of the Central Mountains of North Hungary, in a Turkey oak forest of some extension at a distance of 6 km N—NE from the town of Eger (7).

There is no industrial area in the neighbourhood. The site is separated from the town of Eger by a chain of mountains. Its climatic conditions, however, are nearer to those of the Great Hungarian Plain. Its soil, a clayey deposit, belongs to the group of brown forest soils.

The air pollution examinations extended to the determination of sedimentary and suspended particulated matter and sulphur and nitrogen oxides. In addition, we examined the 3,4-benzo-pyrene content of the soil and plant samples.

* "Sikfőkut Project" No. 25

Methods

In the case of air pollution examinations, the measurements were generally taken twice a month, at three points of the Project area. The determination of the sedimentary dust, sulphur dioxide, suspended dust and nitrogen oxides was made by means of the "Uniform air pollution testing methods" (5) published by the National Institute of Public Health in 1972. Total sulphur content was determined by the Liesegang-type process (13).

The quantity of the depositing dust, suspended particulate matter and total sulphur were measured 1.2 m above ground — below the crown of the trees — and at a height of 25 m, above the crown of the trees. The other pollutants examined were measured at 1.2 m.

The soil and plant samples were taken in agreement with the rules of sampling (22).

The soil samples were taken from depths of 0—5, 5—10, 10—15, 40—50, 90—100 cm, at several points, in spring and in summer. After drying, quantities of 1.0—1.2 kg were processed.

The plant samples were collected in various seasons of the year (spring, summer and autumn). After drying, quantities of 80—220 g were processed. From the solid experimental material which was dried in the dark at 45°C up to body-balance, the constituent parts (which are soluble in benzol) were removed by extraction for 15 hours in a Soxleth apparatus. The 3,4 benzo-pyrene was separated from the extract by means of SÁRINGER's method (11, 10), with layer chromatography, and its quantity was measured with the help of a spectrophotometer.

According to our experiences, the quantity of the specimens to be processed is to be adapted thus that the solution to be used in the photometry will contain at least 0.2 μg/ml of 3,4 benzo-pyrene. If it contains less than that quantity, the separation of 3,4 benzo-pyrene cannot be checked by spectrophotometer.

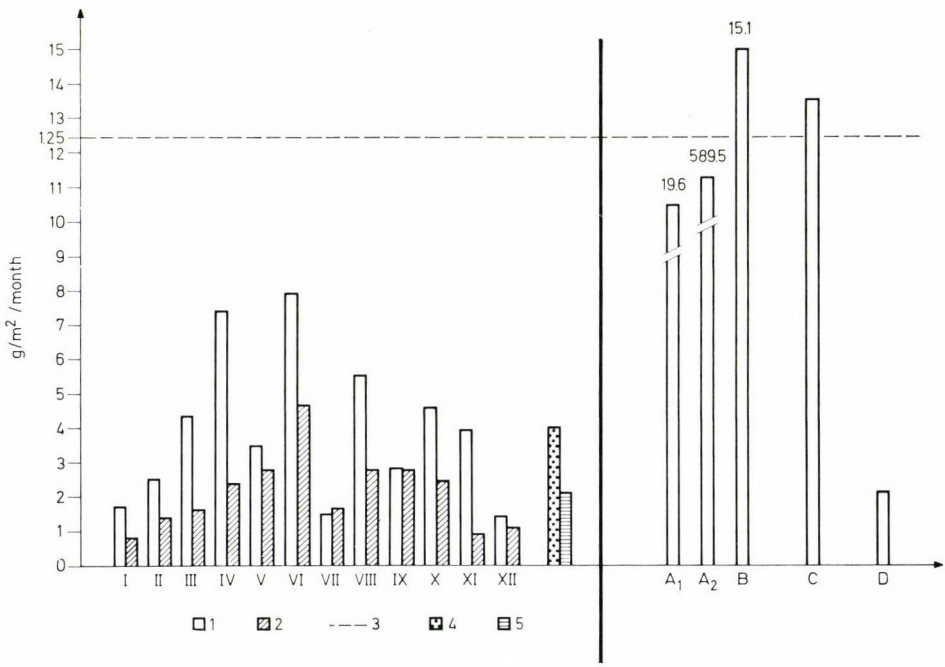


Fig. 1. Monthly and yearly averages of the results of sedimentation examinations (1973—1975). 1 = monthly average at 1.2 m; 2 = monthly average at 25 m; 3 = limit value of hygiene; 4 = yearly average at 1.2 m; 5 = yearly average at 25 m. The columns marked by capital letters refer to data from the literature (yearly averages). A_1 = from the inhabited area of Miskolc; A_2 = from the industrial area of Miskolc; B = from the area of Debrecen; C = from the area of Budapest; D = from the surface of the Lake Balaton

Results

The quantity of the sedimentary dust was measured at a height of 1.2 m and at 25 m above ground (Fig. 1). Its value varied between 0.88 and 8.0 g(m^2) month; at a height of 25 m, that is, above the crown of the trees, the sedimentary dust was about the half of that measured at 1.2 m. The yearly average is 32% at a height of 1.2 m, while it is only 17.5% at 25 m, of the hygienic limit value.

The value of the sedimentary dust measured in our towns (1, 2, 4) is in every case the multiple of that in our samples. In certain industrial workshop areas it even reaches a value hundred times more than that.

The quantity of the suspended particulated matter in the air is shown in Fig. 2.

Its measurement was taken with a coniometer, therefore it is only of an informatory character. Its value varies between 1.5 and 21.2 grains/ml. The quantity of the suspended particulate matter measured above the crown of the trees (the average of 3 years is 4.5) is about the half of that measured below the crown of the trees (3 years' average is 8.5).

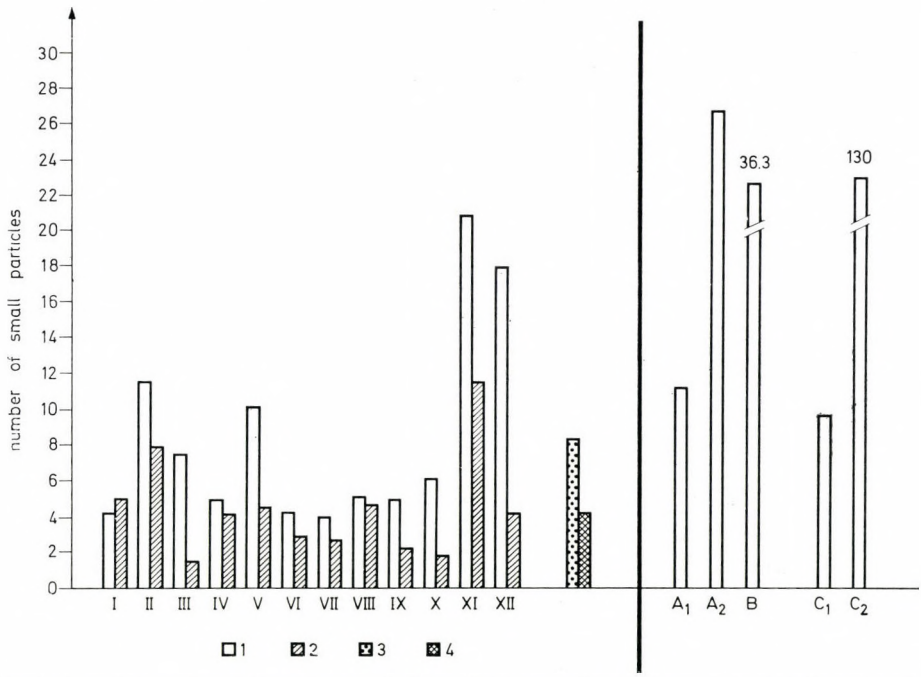


Fig. 2. Monthly and yearly averages of the sedimentary dust value of the air. 1 = monthly average at 1.2 m; 2 = monthly average at 25 m; 3 = yearly average at 1.2 m; 4 = yearly average at 25 m. The columns marked with capital letters refer to data from the literature (yearly averages). A_1 = from the inhabited area of Miskolc; A_2 = from the industrial area of Miskolc; B = from the inhabited area of Debrecen; C_1 = from the inhabited area of Budapest; C_2 = from traffic junctions in Budapest

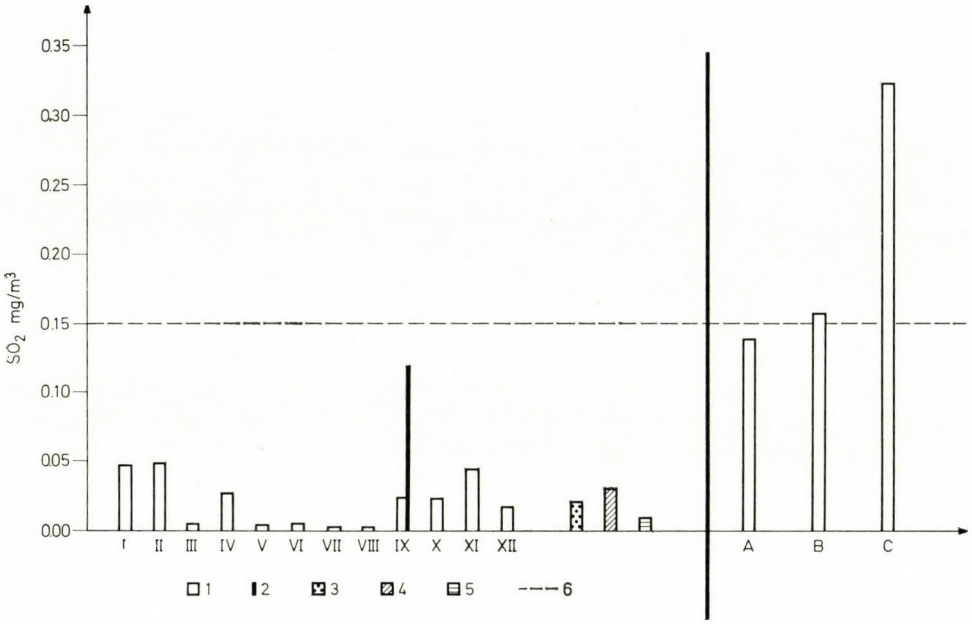


Fig. 3. Monthly and yearly averages of the sulphur dioxide content of the air. 1 = monthly average; 2 = a working machine in operation during the measurement; 3 = yearly average; 4 = the average during the heating season; 5 = the average during the non-heating period; 6 = hygienic limit value. The columns marked with capital letters refer to data from the literature (yearly averages). A = from the area of Miskolc; B = from the area of Debrecen; C = from the area of Budapest

The sulphur dioxide quantity of the air is shown in Fig. 3.

The values obtained are very low. The sulphur dioxide content of the air varies between 0.001—0.05 mg/m³, which is far below the hygienic limit value. The 3 years' average is 0.021 mg/m³. In the heating season sulphur dioxide quantity is three times higher (0.032) than in the non-heating season (0.01). This means that heating makes its influence felt also here.

It is worthy of note that on the occasion of one of our measurements a machine was operated nearby, as a result of which the quantity of sulphur dioxide measured was five times higher (0.12 mg/m³).

The total sulphur content of the air is given in Fig. 4.

Its value changes between 0.00 and 3.00 mg/100 hours. The 3 years' average at a height of 1.2 m above ground is 0.44 mg/100 hours, while at 25 m it is 0.74 mg/100 hours. The values above the crown of the trees were in general higher than otherwise.

In the heating season, the quantity of the total sulphur content is approximately three times (0.65—1.16) that of the non-heating season (0.24—0.31). Accordingly, sulphur contamination originating from heating can be measured also here.

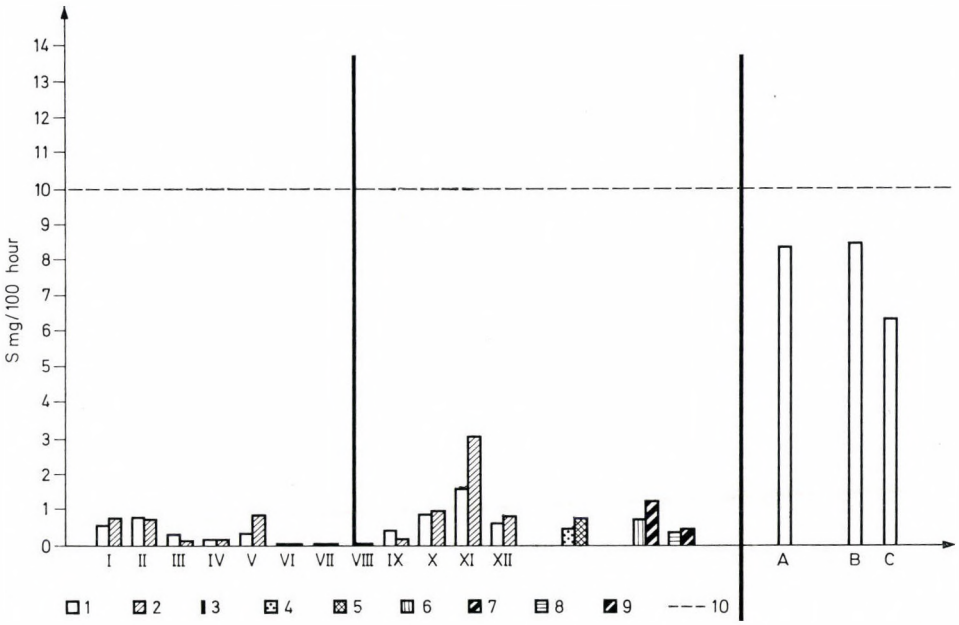


Fig. 4. Monthly and yearly averages of the total sulphur content of the air. 1 = monthly average at 1.2 m; 2 = monthly average at 25 m; 3 = a working machine in operation during the measurement; 4 = yearly average at 25 m; 6 = average at 1.2 m during the heating season; 7 = average at 25 m during the heating season; 8 = average at 1.2 m during the non-heating season; 10 = hygienic limit value. The columns marked with capital letters area data from the literature (yearly averages). A = from the area of Miskolc; B = from the area of Debrecen; C = from the area of Budapest

The operation of the machine in the vicinity — it was digging a trench for cable-laying — showed its effect also in the total sulphur content, when a value of 14.1 mg/100 hours was obtained.

The quantity of nitrogen oxides of the air is shown in Fig. 5.

Its value varies between 0.043—0.005 mg/m^3. The 3 years' average is 0.016 mg/m^3.

Table 1

3,4 benzo-pyrene content of soil samples

Depth of the soil layer, cm	3,4 benzo-pyrene, μg/kg soil
0— 5	3.4
5— 10	1.7
10— 15	2.4
40— 50	1.9
90—100	1.6

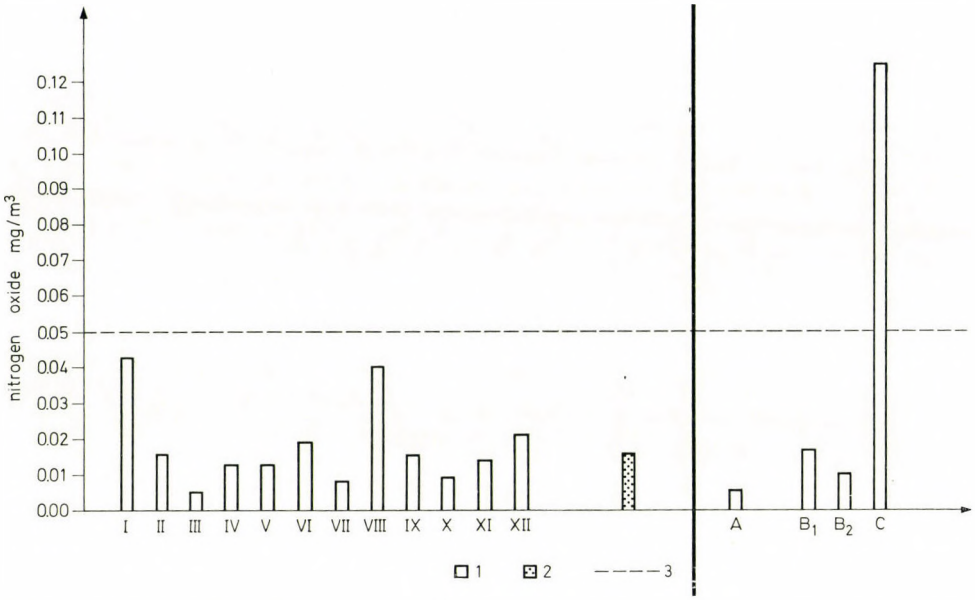


Fig. 5. Monthly and yearly averages of the nitrogen-oxide content of the air. 1 = monthly average; 2 = yearly average; 3 = hygienic limit value. The columns marked with capital letters refer to data from the literature (yearly averages). A = from the area of Miskolc; B_1 = from the area of the Lajos Kossuth University of Sciences, Debrecen; B_2 = from the area of the Boda forest near Debrecen; C = from the area of Budapest

The second part of the examination was the determination of the 3,4-benzo-pyrene content of the soil and of the plant samples.

The 3,4-benzo-pyrene content of the soil samples taken from various depths in the Project area in 1974—1975 is given in Table 1.

The lowest values were found in soil layers 5—10 cm and 90—100 cm, viz. 1.7 μg/kg and 1.6 μg/kg. The highest values, 3.4 μg/kg, was obtained

Table 2

3,4 benzo-pyrene content of plant specimens

Plant specimen	3,4 benzo-pyrene μg/100 g dry material
Upper layer of under-litter soil	3.0
Last-year litter	6.0
Current year's litter	15.0
Moss	7.0
Green under-growth	5.0
Green oak-leaf	1.2
Yellow oak-leaf	1.7

in the 0—5-cm layer. No correlation was found between these values and the depth of the soil stratum.

The quantity of 3,4-benzo-pyrene found in the plant samples collected in the Project area in 1974—1975 is given in Table 2.

For a comparison, we offer the data obtained by WETTIG (21) and MALLETT (14). They found the following quantities of 3,4-benzo-pyrene in the various plant specimens:

Oak leaf	0.8
Beech leaf	1.6
Tobacco leaf	1.2
Lettuce	1.2
Spinach	2.0
Litter	30.0
Under-litter soil layer	6.0

It can be stated that the 3,4-benzo-pyrene content is the highest in samples which underwent decomposition in the given period. So in 100 g dry matter of the litter in 1974 15 μg 3,4-benzo-pyrene was found. The smallest quantity was found in the dry material of green oak leaf; 1.2 μg 3,4-benzo-pyrene was found in 100 g dry material.

Discussion

The determination of the background values of the substances polluting the atmosphere has so far been treated by very few authors in Hungary. VÁRKONYI (20) was the first to measure one of the most important contamination substances, sulphur dioxide, with a coverage of the whole country. On the basis of his data, the sulphur dioxide background of the air in the clearest part of the country (the Comitats Baranya and Csongrád) is of an identical order of magnitude with our data measured at Sikfőkut. Concerning the other pollutants, no similar background measurements had taken place.

In the figures, along with our experimental results, literature data have also been indicated, thus providing a possibility of comparisons.

Accordingly, it can be stated that the quantity of the sedimentary dust measured above the crown of the trees shows an agreement with that measured by Mórik above the Lake Balaton (16). The quantity of the suspended particulate matter found was considerably lower than that measured in air samples taken from inhabited areas (2, 8, 17).

The value of both the sulphur dioxide and the total sulphur content is only one-tenth of that found in the air of our inhabited areas (2, 4, 17).

The nitrogen oxide content of the air shows an agreement with the average values of 0.010 mg/m^3 measured in the Boda Forest near Debrecen (15). The quantities of nitrogen oxide are nearly identical in the air of Debrecen and Miskolc. It is remarkable, that in the air of Budapest, measured in 1973 (4), it is very high (0.125 mg/m^3).

On the basis of our measurements we may state that in the area examined — and also in those similar to this area — one has to reckon with an air pollution of some slight extent. This adds up from the pollution of the natural background and from the pollution caused by civilization. We cannot separate them. Therefore, we can only estimate the value of the real natural background.

We can state that at present it is not likely that in Hungary an area would exist where only the natural background pollution, taken in an absolute sense, may occur. Nevertheless, we can say that the air pollution values measured here can be considered as the basic background values of the air pollution of this region, at this time.

It would be necessary — at least occassionally — to make similar surveys also at other points of the country. Thus, in the course of time, one could assess changes in the present background under the effect of civilization.

The data of 3,4-benzo-pyrene determinations were compared with those of investigations made in other countries. BORNEFF examined soil samples of German forests and he found 0.5 –4 μg/kg 3,4-benzo-pyrene in them (3).

SHABED and his co-workers examined 300 samples taken from the soil of various forests in the Soviet Union (18); 83% of the samples contained 1—3 μg/kg 3,4-benzo-pyrene, while the rest contained 3—10 μg/kg of it. The dust samples of the great cities — also of those in Hungary — contain from ten to thousand times more 3,4-benzo-pyrene than that shown by the background values found in our research area (9, 12, 19).

On the basis of the 3,4-benzo-pyrene examinations of the soil and of plant samples it can be stated that in Hungary the quantity of 3,4-benzo-pyrene appearing in the soil samples taken from the forest at Sikfőkut is identical with that found in the soil samples of Soviet and German forests. This means that in these areas — and probably also in other similar areas — the soil is not yet contaminated. Thus, one may suppose that the measured quantity of 3,4-benzo-pyrene represents the real background level.

Concerning the origin of the background level, one might mention forest fires and it is probably that certain *Clostridium* species synthesize, during their metabolism, the polycyclic aromatic hydrocarbons. Besides, they can get into the soil by the decomposition of plants and from the groundwaters.

The polycyclic aromatic hydrocarbon content of plants originates from three sources: from the air, from the soil, and from synthesis. Concerning the latter, it has been proved that a plant can perform a kind of endogenic

synthesis. GRÄF and DIEHL (6) found 3,4-benzo-pyrene in the flora and fauna of sea regions where no kind of external source of pollution could be found. For the final proof of this endogenic synthesis, various seeds were germinated in an absolutely hydrocarbon-free environment. The 3,4-benzo-pyrene content was determined before and after germination. It was established that the various seeds contained 20—40 times more 3,4-benzo-pyrene after germination than before.

Investigation of the environmental carcinogenes is a very important task. These determinations can serve as guidelines as regards, on the one hand, the quantity of carcinogenic substances accumulating in our environment, and the extent of elimination, on the other. By this, research provides the protection of environment with concrete data in the struggle against cancer.

Summary

The author determined the 3,4-benzo-pyrene content and the air pollution of plant and soil samples taken from the self-preserving ecosystem of an oak-forest considered as relatively undisturbed up to the present time. The aim of the air pollution examination, conducted for three years, was to determine the background values for the various pollutants.

The yearly average value of the sedimentary dust was 4.05 g/m^2/month at a height of 1.2 m above ground, and 2.2 g/m^2/month at a height of 25 m above ground.

The yearly average of the suspended particulate matter in the air was 8.5 grains/ml at a height of 1.2 m above ground, and 4.5 grains/ml at a height of 25 m above ground.

The yearly average of the sulphur dioxide content of the air was 0.021 mg/m^3.

The three-years' average of the total sulphur quantity was 0.44 mg/100 hours at a height of 1.2 m above ground, and 0.74 mg/100 hours at 25 m above ground.

The yearly average of the nitrogen oxide contamination of the air was 0.016 mg/m^3.

The soil samples were taken from depths of 0—5, 5—10, 10—15, 40—50 and 90—100 cm. The quantity of benzo-pyrene found in the samples was 1.6—3.4 μg/kg.

The 3,4-benzo-pyrene content of 100 g dry material, obtained from the seven kinds of plant samples examined (litter underneath — above-ground layer; last year's litter; this year's litter; moss; green underwood; green oakwood leaf; yellow oakwood leaf), was 1.2—15 μg.

Assumably, the 3,4-benzo-pyrene value obtained in the measurement still agrees with the real background level.

REFERENCES

1. Bíró Zs., Csokonay J-né, Gábos L-né (1976): Debrecen, Nyíregyháza, Szolnok városok levegőszennyezettségi helyzete (1974—75-ben. (Hung.) (The conditions with regard to air pollution in the towns Debrecen, Nyíregyháza, and Szolnok) Hung. Egészségtudomány **20,** 247—255.
2. Bíró Zs., Puszta B. (1973): Borsod-Abaúj-Zemplén megye és Miskolc város levegőszennyezettségi helyzete az 1956—1971. években történt felmérések alapján (The conditions with regard to the air pollution in Comitat Borsod-Abaúj-Zemplén and of the town Miskolc, on the basis of surveys made between 1956 and 1971) (Hung.) Miskolc.
3. Borneff J., Kunte H. (1963): Kanzerogene Substanzen in Wasser und Boden. Arch. Hyg. **147,** 401—409.
4. Budapest Fővárosi Közegészségügyi-Járványügyi Állomás Évkönyve (Hung.) (Yearbook of the Institute of Public Hygiene and Epidemics of the City of Budapest). Budapest 1974.
5. Egységes levegővizsgáló módszerek (Uniform air-pollution testing methods). Országos Közegészségügyi Intézet (National Institute of Public Health), Budapest, 1972.
6. Gräf W., H. Diehl *cit.* Wetting K. (19)
7. Jakucs, P.: "Sikfőkút Project". Egy tölgyes ökoszisztéma környezetbiológiai kutatása a bioszféra program keretén belül ("Sikfőkút Project". Environmental-biological research of an oakwood ecosystem, within the framework of the biosphere programme) (Hung.) MTA. Biol. Oszt. Közl. **16,** 11—25.
8. Kelenffy Sz., Mórik J. (1967): A közlekedés okozta légszennyeződés vizsgálatának néhány eredménye (Some results of examinations concerning air pollution caused by traffic). Hung. Időjárás **71,** 227—231.
9. Kertai P. (1973): Carcinogén anyagok a környezetben (Carcinogenic materials in the environment). Egészségtudomány: **17,** 297—309.
10. Kertészné Sáringer M. (1960): Vizsgálatok a 3,4-benzpyrén analitikája köréből. (Examinations from the sphere of 3,4-benzo-pyrene analytics) (Doctorate thesis). Budapest.
11. Kertészné, Sáringer M. (1960): A vékonyréteg-chromatographiás eljárás alkalmazása a levegőből nyert porminták 3,4-benzpyrén tartalmának meghatározásánál. (Application of the thin-layer chromatographic method in the determination of the 3,4-benzopyrene content of dust samples obtained from the air) (Hung.). Egészségtudomány **12,** 129—134.
12. Kertészné Sáringer M., Mórik J. (1970): Városi és falusi településeken, valamint ipari üzemekben gyűjtött porminták 3,4-benzpyrén tartalma (The 3,4-benzo-pyrene content of dust samples taken from inhabited areas of towns and villages and from industrial plants). Egészségtudomány **14,** 105—115.
13. Liesegang, W. (1931): Schwefelbestimmung mit Glocken-Methoden. Gesundh. Ing. **52,** 48—54.
14. Mallett L. (1972): Pollutions des milieux vitaux par les hydrocarbures cancérigènes. Paris.
15. Medve F., Mórik J., Péter F-né (1971): A levegő nitrogén-dioxid szennyezettsége földgáz tüzelésű fűtőmű környezetében (Nitrogen-dioxide contamination of the air in the surroundings of a power station heated with natural gas). Egészségtudomány **15,** 369—372.
16. Mórik J., Záborszky K. (1966): Az ülepedőpor mennyiségének vizsgálata a Balaton térségében. (Examination of the quantity of sedimentary dust in the region of the Lake Balaton). Egészségtudomány **10,** 275—281.
17. Péter F-né (1969): Debrecen levegőhigiénés helyzetének komplex vizsgálata (Hung.) Doktori értekezés, Debrecen (Complex analysis of the air hygienic conditions of Debrecen). (Doctorate thesis)
18. Shabad L. M. et al. (1971): The Carcinogenic Hydrocarbon Benzo (a)-pyrene in the Soil. J. Nat. Cancer Inst. **47,** 1179—1191 (1971) .
19. Six L-né, Kertészné Sáringer M. (1971): Levegőszennyeződési vizsgálatok Sopron város területén (Air-pollution tests in the area of the town Sopron). Egészségtudomány **15,** 358—368.
20. Várkonyi T. (1972): A regionális kéndioxid szennyeződés vizsgálata a Dunántúlon. (Hung.) Biol. med. doktori értekezés. (Examination of the regional sulphur dioxide contamination in Transdanubia) (Biol. med. doctorate thesis), Debrecen, 1972.
21. Wettig K. (1971): Neuere Anschauungen über die kanzerogene Aktivität von polyzyklischen Kohlenwasserstoffen in der Biosphäre. Z. Ges. Hyg. **17,** 667—670.
22. Erdey L.—Mázor L. (1974): Analitikai Kézikönyv (Analytical Handbook), Műszaki Könyvkiadó, Budapest 1974.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (3—4), pp. 403—414 (1976)

NUMERICAL TAXONOMIC STUDIES ON IRIS PUMILA L. BY CLUSTER ANALYSIS

By

E. MELKÓ

BOTANICAL RESEARCH INSTITUTE, HUNGARIAN ACADEMY OF SCIENCES, VÁCRÁTÓT

(Received June 10, 1976)

ORLOCI's agglomerative cluster analysis is described first, then applied to the geographical and taxonomical clustering of *Iris pumila* L., and finally the results are assessed.

The material consisted of the herbarium specimens of *Iris pumila* L., obtained from some 35 localities of the Carpathian Basin (+ one from the Ukraine). The basis of the examinations was provided by the 14 (absolute) sizes measured on the leaves and on the perigone of the plant, and by 12 ratios formed from the absolute sizes.

By applying ORLOCI's agglomerative cluster analysis, 4 analyses were carried out. The results show that, although the clusters obtained by the analyses were fairly well-distinguishable in each of the cases, the individual clusters are not homogeneous either geographically (according to locality, base rock, and altitude) or with regard to the traditional infraspecific taxonomical classifications.

By inference it can be said that on the basis of the vegetative part sizes and of the ratios formed from them, *Iris pumila* L., in the area examined (in the Carpathian Basin), cannot be classified into homogeneous groups either geographically or according to the current taxonomical classifications.

The examinations indicate that the cluster analyses are suitable for the solution of taxonomical tasks. By their means, on the basis of characteristic qualities, the species examined can be grouped and it can be shown whether the clusters originally considered as homogeneous are indeed homogeneous.

I. Introduction

1.1. The present paper is actually a study of methodology. Our primary aim was to try out and present one of the methods of cluster analysis, the agglomerative procedure of ORLOCI.

By means of the above method, we carried out two types of clustering during our work, namely we examined

— how the *Iris pumila* individuals originating from a geographically large area form a group;

— whether the infraspecific taxa are distinct.

1.2. In phytotaxonomy, the classification has been and is even today based on more or less subjective elements; however, in 1950—1960 attempts were made to increase objectivity (in connection with this cf. GOODALL's remark, 1973).

Numerical taxonomy, within certain limits, endeavours to attain an objective classification. Its methods are based on multivariate statistical analyses or these analyses have been borrowed in toto. The methods elaborated for the classification of vegetation have had a great influence on the development of numerical taxonomy. In the classification of the vegetation units, cluster analysis, which is actually an analysis family, was used effectively.

By means of cluster analyses, we can explore objectively and unambigously the 'natural'

clusters of the individuals by taking into account a random number of their characteristics.

The first fundamental textbook of numerical taxonomy was published in 1963 (SOKAL, R. R.—SNEATH, P. H. A., 1963), while the first summarizing textbook of cluster analyses in 1971 (JARDINE, N.—SIBSON, R., 1971). GOODALL (1973) gives a summary of the fundamental questions of numerical classification, of its basic principle, methods and of the cluster analyses.

1.3. Cluster analyses can be classified into two large groups:

1. Divisive cluster analyses
2. Agglomerative cluster analyses.

The point of departure in the divisive methods is the set of all individuals examined, which then are successively broken down at the beginning into large, then gradually into smaller clusters, then into individuals.

With the agglomerative methods the approach is reversed: starting from the individuals, we build up the clusters of gradually increasing size by successive contractions up to the maximum-size cluster which then contains all the individuals.

The result of the analysis in both cases is the division between the two endpoints, that is the classification of the individuals into a certain number of clusters. The determination of the point where we stop dividing or contracting varies according to the methods.

When we examine individuals m and measure qualities n in each of them, the data matrix will be of size $m \times n$. Let us consider the individuals as points in a Euclidean space of dimension n. The position of these points are determined by the quality values as coordinates. Thus every axis corresponds to a quality and vica versa. Every individual is represented by one and only one point on the various axes. When the individuals form a cluster or clusters' this must be reflected by the arrangements of the points.

II. Method and material

II.1. ORLOCI's aggomerative cluster analysis. One of the most wide-spread of the clusteanalyses is ORLOCI's agglomerative cluster analysis. It has a number of advantageous characteristics: it is based on natural principles, relatively simple, and easy to interpret.

The basic principle of ORLOCI's method is that it decreases to the minimum the variance at every level within the group and it increases to the maximum the variance between the groups. This can be applied for both the presence and absence data as well as in the case of quantitative data. The distance between samples j and k is:

$$D_{jk} = \sqrt{\sum_i \left(\frac{x_{ij}}{v_j} - \frac{x_{ik}}{v_k} \right)^2} ,$$

where x_{ij} is the value of the i-th variable in the j-th sample, while v_j is the length of the j-th vector, i.e.
$\sqrt{\sum_i x_{ij}^2}$. Standard deviation within one group containing samples M is:

$$Q = \left\{ \sum_{j=1}^{M} \sum_{k=j+1}^{M} D_{jk}^2 \right\} \Big/ M$$

At the beginning of the analysis, each of the points is regarded as a separate cluster, while the increasingly larger clusters containing the smaller ones are formed by successive contractions.

During the contractions the following rule must be kept: we contract always those clusters (only two at a step) which increase to a smaller extent their internal variance by the contraction than they would do in any other kind of contraction. At the first step, according to the above rule, we actually contract the points "nearest to one another" (the ones among which the Euclidan distance is the smallest). To the cluster (i.e. to the pair) thus formed, a third sample etc. The formation of groups, i.e. their clustering, continues step by step up to the point where all members of the sample belong to one cluster. In this way clustering between the various groups may at each level take place only in a way of having a minimum standard deviation within the groups while, at the same time the standard deviation between the groups is at the maximum level.

A significance test for reliability of clustering can also be made by ORLOCI's clustering. This method is in many respects similar to the simplest case of the analysis of variance, where

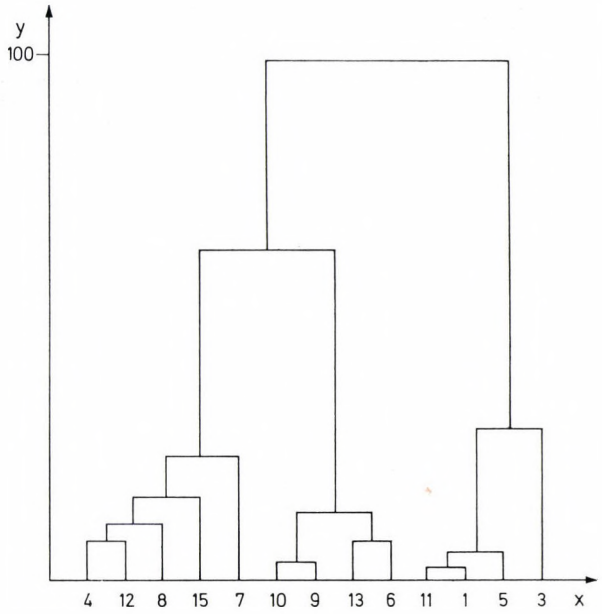


Fig. 1. Demonstration of the cluster analysis by means of a dendrogram (Nos 1, 2, 3 etc. indicate individuals)

the total variance is broken down into variance between clusters and into variance within clusters, but it is not identical with that case.

We demonstrate the result of the cluster analysis by means of dendrograms. On axis *X* in Fig. 1, the individuals are located in a reasonable but random order so that the connecting lines cannot intercept each other. On axis *Y* the ratio of cluster internal variance and total variance is indicated in percentage. The total variance is obtained by adding up the variances between the groups and those within the groups (GOODALL 1973).

The individuals connected with a line belong to one cluster. The height of the horizontal connecting line, its value *Y*, indicates the percentage accounted for the particular cluster within the total variance, i.e. the degree of closeness in clustering of its constituting elements. From this, also the distance between the various points can be inferred.

The FORTRAN programme of ORLOCI's agglomerative cluster analysis was produced by GOLDSTEIN and GRIGAL (1972), while I carried out the runs on the CDC 3300 computer of the HAS.

II. 2. We borrowed for our work some 260 herbarial sheets of *Iris pumila* L. from the herbarium of the Phytotaxonomical and Ecological Department of the EÖTVÖS LÓRÁND University and from that of the Botanical Department of the Natural History Museum. I selected 50 specimens each of the two collections by taking into consideration the following points:

the samples should

- be whole, with flowers, i.e. be in the same phenophase;
- contain specimens dried satisfactorily;
- have well-measurable characteristics;
- originate from geographically different localities (for example, the Viennese Basin, the Great Hungarian Plain, Transylvania, the Ukraine; the localities are indicated in Figs 3—8, with the appropriate taxonomical designations;
- belong to various infraspecific taxa, according to the identificator; for example: var. *scapifera*, *transsilvanica*, f. *lutea*, etc.

In agreement with these viewpoints, I was able to use also the valuable herbarial specimens which had been collected a long time ago. Collection *A* is formed from the 50 specimens obtained from the herbarium of the EÖTVÖS LORÁND University, while those originating from the Botanical Department of the Natural History Museum appear in collection *B*.

I made an exact copy of each of the 50 selected individuals (Fig. 2), and measuring was made on the copies. At the drawing and in measuring only the leaves and the length of the perigone were considered, the flower parts not. The flower will namely become strongly deformed at drying (even its colour becomes undistinguishable), and, if I had measured the flower parts, I should have torn the flowers into parts, certainly not to be done with borrowed herbarial specimens. I carried out the measurements by the so-called localized sampling (HORÁNSZKY—SZŐCS 1972).

I considered and measured 14 characteristics in each individual (Fig. 2):

The morphological characteristics used for
Analysis 1 (see also Fig. 2)

V1 — Number of leaves
V2 — The lengths of floral axis, ovary, and perigone together
V3 — Length of leaf margin I (left)
V4 — Length of leaf margin I (right)
V5 — Length of leaf I
V6 — Largest diameter of leaf I
V7 — Length of leaf margin II (left)
V8 — Length of leaf margin II (right)
V9 — Length of leaf II
V10 — Largest diameter of leaf II
V11 — Length of leaf margin III (left)
V12 — Length of leaf margin III (right)
V13 — Length of leaf III
V14 — Largest diameter of leaf III

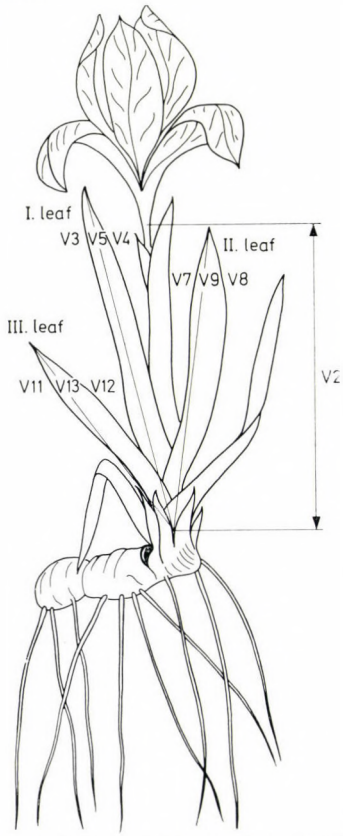


Fig. 2. The points of measurements and the variables in the individuals (for keys to the symbols see Table 1)

Variables V2, V3, V4, V5, V7, V8, V9, V11, V12 and V13 were measured to mm accuracy, while variables V6, V10 and V14 to decimal mm accuracy.

The characteristics used for Analysis 2 (ratios)

W1 = V2/V5 — Floral axis, ovary and perigone lengths together/length of leaf I
W2 = V2/V9 — Floral axis, ovary and perigone lengths—together/length of leaf II
W3 = V2/V13 — Floral axis, ovary and perigone lengths together/length of leaf III
W4 = V5/V6 — Length of Leaf I/largest diameter of leaf I
W5 = V9/V10 — Length of leaf II/largest diameter of leaf II
W6 = V13/V14 — Length of leaf III/largest diameter of leaf III
W7 = V3/V4 — Left leaf margin length of leaf I./right leaf margin I length
W8 = V7/V8 — Left leaf margin II length/right leaf margin II length
W9 = V11/V12 — Left leaf margin III length/right leaf margin III length
W10= V5/V13 — Length of leaf I/length of leaf III
W11= V5/V9 — Length of leaf I/length of leaf II
W12= V9/V13 — Length of leaf III/length of leaf III

In order to be able to filter out the variability caused by environmental factors, I calculated the ratio numbers of the absolute values, see the enumeration of ratios above. For it is presumable that the length and width of the leaves vary under the effect of environmental factors, whereas the ratio of their length and width is relatively constant and characteristic. Thus, I carried out altogether four analyses:

1/I. Examination of geographical groups on the basis of absolute numbers;
1/II. Examination of geographical groups on the basis of ratio numbers;
2/I. Examination of infraspecific taxa on the basis of absolute numbers;
2/II. Examination of infraspecific taxa on the basis of ratio numbers.

III. Results and their discussion

Analysis 1/I. — Examination of geographical groups on the basis of absolute measures of the vegetative parts (Figs 3 and 5)

Collection A

On the basis of the absolute measurements of the vegetative parts, it can be stated that the *Iris pumila* collection consisting of the 50 individuals and originating from localities which lie geographically far apart from one another (Viennese Basin, the Buda Hills, Great Hungarian Plain, Transylvania, Ukraine) does not separate into homogeneous geographical groups (Fig. 3). It is remarkable that individual No. 37, which originates from the Ukraine (Krasnogorka), does not separate from the others either.

Since the collection was extremely varied also by the basic rock and altitude (dolomite, loess, granite, andesite, sand, etc., and altitudes of 100—600 m), I made an attempt to asses the dendrogram also by taking these viewpoints into consideration, but the clusters obtained did not turn out to be homogeneous in this way either.

Collection B

This collection, which originates from an even larger area, cannot be separated into homogeneous geographical groups either (Fig. 5).

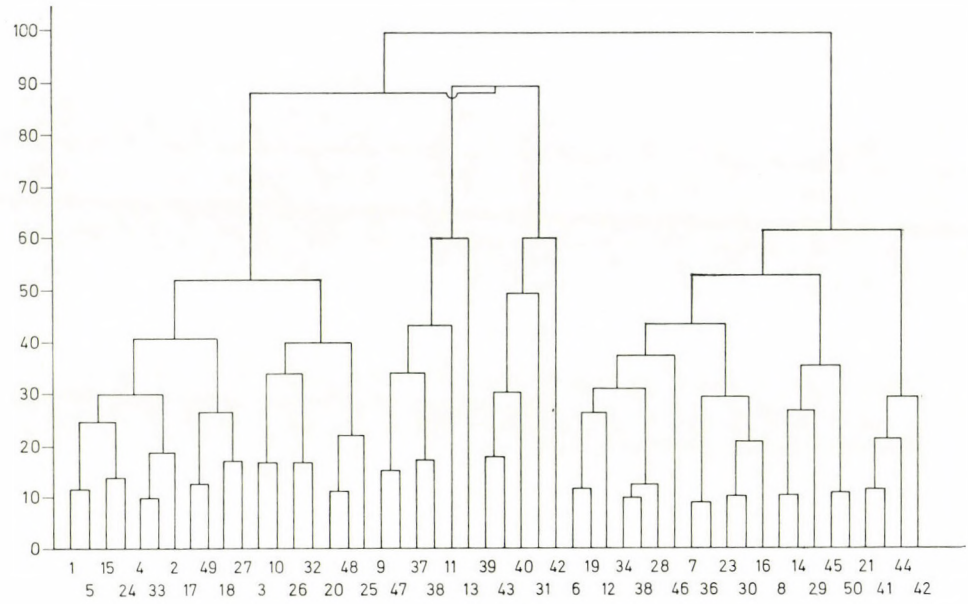


Fig. 3. Analysis 1/I — Dendrogram of Collection A. Symbols:

1: *I. pumila* — Bécsi medence (Viennese Basin)
2: *I. pumila* — Naszály
3: *Iris pumila* — Naszály
4: *I. pumila* — Dorog
5: *I. pumila* — Dorog
6: *I. pumila* — Bécsi medence
7: *I. pumila* — Bécsi medence
8: *I. pumila* — Budai hegység (Buda Hills)
9: *I. pumila* — Budai hg.
10: *I. pumila* — Naszály
11: *I. pumila* — Horgos
12: *I. pumila* — Törökugrató
13: *I. pumila* — Káposztásmegyer
14: *I. pumila* f. *flava* — Budapest
15: *I. pumila* — Budai hg.
16: *I. pumila* — Budai hg.
17: *I. pumila* — Soroksár
18: *I. pumila* — Soroksár
19: *I. pumila* — Wien
20: *I. pumila* — Sashegy
21: *I. pumila* — Sashegy
22: *I. pumila* — Sashegy
23: *I. pumila* — Svábhegy
24: *I. pumila* — Svábhegy
25: *I. pumila* — Svábhegy
26: *I. pumila* — Farkasvölgy
27: *I. pumila* — Soroksár
28: *I. pumila* — Horgos
29: *I. pumila* — Sashegy
30: *I. pumila* — Sashegy
31: *I. pumila* — Budai hg.
32: *I. pumila* — Nadap
33: *I. pumila* — Szarvaskő
34: *I. pumila* — Hármashatárhegy
35: *I. pumila* — Hármashatárh.
36: *I. pumila* — Pozsony
37: *I. pumila* — Krasznogorka
38: *I. pumila* — Horgos
39: *I. pumila* var. *scapifera* — Hosszúaszó
40: *I. pumila* f. *coerulea* — Budai hg.
41: *I. pumila* f. *lutea* — Hármashatárh.
42: *I. pumila* — Svábhegy
43: *I. pumila* — Budaújlak
44: *I. pumila* — Káposztásmegyer
45: *I. pumila* — Káposztásmegyer
46: *I. pumila* — Hármashatárh.
47: *I. pumila* — Hármashatárh.
48: *I. pumila* — Hármashatárh.
49: *I. pumila* — Svábhegy
50: *I. pumila* f. *coerulea* — Budai hg.

In summary, it can be stated that, even though in Analysis 1/I the dendrograms of both of the collections present clusters which separate fairly well, these cannot be interpreted on the basis of the above viewpoints.

Analysis 1/II — Examination of geographical groups on the basis of ratio numbers obtained from the measures of vegetative parts (Figs 4 and 6)

Collection A

Similarly to Analysis 1/I/*A*, here we find also well-distinguishable clusters (for example, 30—33—1—40), which, however, are not geographically homogeneous either (Fig. 4). In Analysis 1/II/*A*, dissimilarly to Analysis 1/I/*A*, the Ukrainean specimen No. 37 separates into an independent cluster (Figs 4 and 3).

Collection B

The collection cannot be broken down into homogeneous geographical groups on the basis of ratio numbers either, although it is divisible into well-separating clusters (for example 17—42 or 14—27—11—48—15—19 in Fig. 6).

As a summary it can be stated that Analysis 1/II resulted in clusters considerably different from that of 1/I: the clusters were completely re-arranged. None of them was, however, interpretable on the basis of geographical

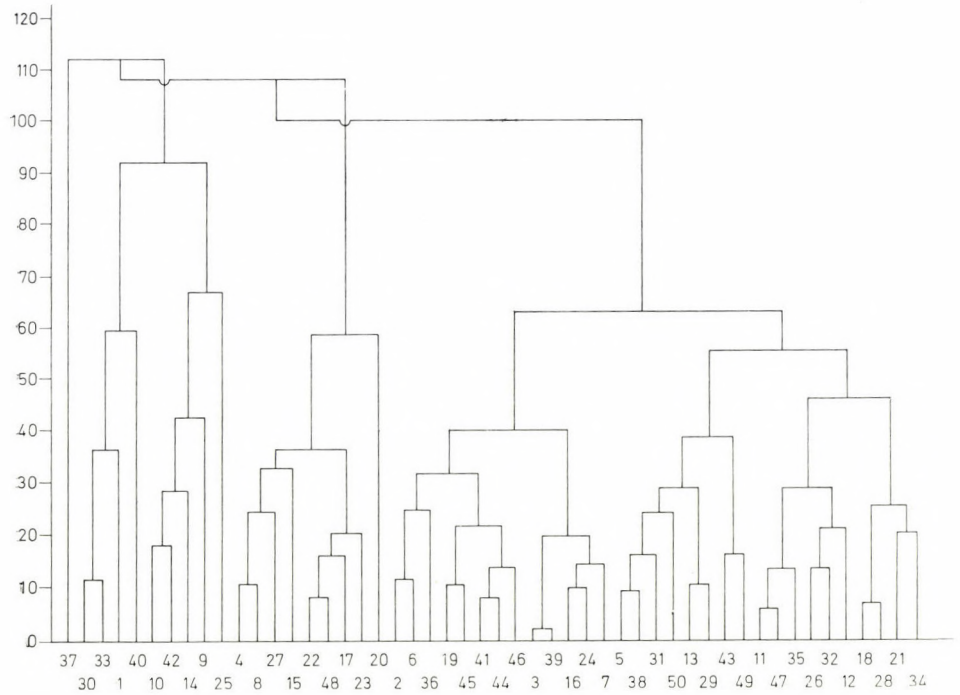


Fig. 4. Analysis 1/II — Dendrogram of Collection A. For symbols see Fig. 3.

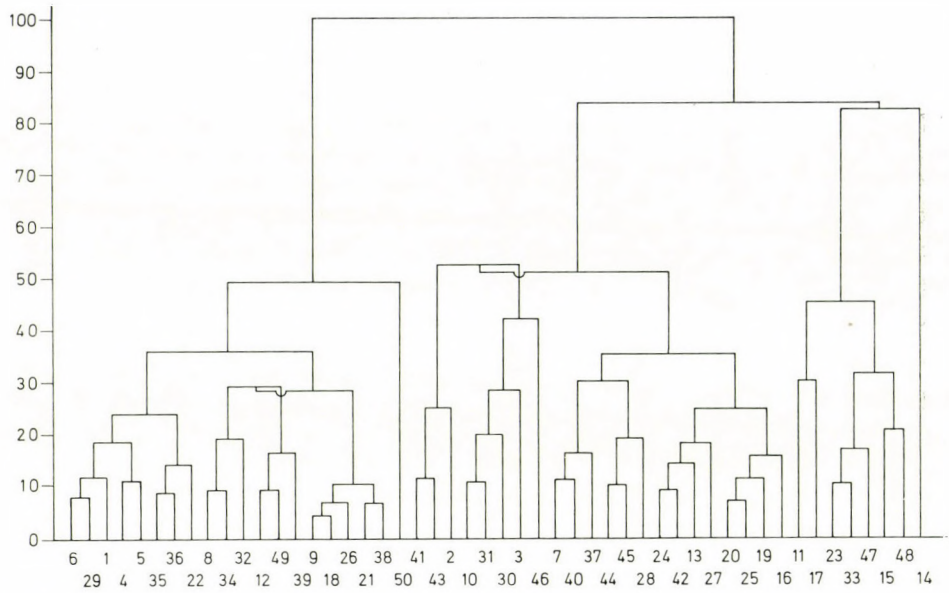


Fig. 5. Analysis 1/I — Collection B and Analysis 2/I — Dendrogram of Collection B. Symbols

1: *I. pumila* v. *lutea* — Tállya
2: *I. pumila* v. *lutea* — Füzér
3: *I. pumila* v. *lutea* — Füzér
4: *I. pumila* v. *lutea* — Sopron
5: *I. p.* f. *lutea* — Kolozsvár
6: *I. p.* f. *lutea* — Kolozsvár
7: *I. p.* var. *lutea* — Buda
8: *I. p.* var. *lutea* — Buda
9: *I. p. trans.* var. *flaviflora* — Nagyszeben
10: *I. p. trans.* var. *flaviflora* — Nagyszeben
11: *I. p.* var. *scapifera* — Budai hg.
12: *I. transsilvanica* — Budai hg.
13: *I. transsilvanica* — Budai hg.
14: *I. transsilvanica* — Hosszúaszó
15: *I. transsilvanica* — Hosszúaszó
16: *I. transsilvanica* — Hosszúaszó
17: *I. transsilvanica* — Hosszúaszó
18: *I. trans.* f. *flava* — Transsilvania
19: *I. trans.* f. *flava* — Transsilvania
20: *I. transsilvanica* — Sash.
21: *I. transsilvanica* — Szászsebes
22: *I. transsilvanica* — Nagyenyed
23: *I. transsilvanica* — Nagyenyed
24: *I. transsilvanica* — Nagyenyed
25: *I. transsilvanica* — Szászsebes
26: *I. transsilvanica* — Transsilvania
27: *I. transsilvanica* — Szászsebes
28: *I. transsilvanica* — Szászsebes
29: *I. p. prol. trans.* — Kolozsvár
30: *I. p. prol. trans.* — Szászsebes
31: *I. transsilvanica* — Szászsebes
32: *I. pumila* — Kolozsvár
33: *I. pumila* — Dorog
34: *I. pumila* — Sátoraljaújhely
35: *I. lutescens* — Kolozsvár
36: *I. pumila* — Torda
37: *I. pumila* — Hármashatárh.
38: *I. pumila* — Hármashatárh.
39: *I. pumila* — Borsod, Bálványh.
40: *I. pumila* — Borsod, Bálványh.
41: *I. pumila* — Csákvár
42: *I. pumila* — Csákvár
43: *I. pumila* — Kisvárda
44: *I. pumila* — Törökbálint
45: *I. pumila* f. *flava* — Budai hg.
46: *I. pumila* f. *flava* — Budai hg.
47: *I. p.* var. *scapifera* — Hosszúaszó
48: *I. pumila* — Budai hg.
49: *I. p.* f. *lutea* — Hármashatárh.
50: *I. pumila* — Budai hg.

viewpoints, that is, the clusters obtained were not geographically homogeneous. It can accordingly be inferred that on the basis of the measurements examined with regard to the vegetative parts — considering either the absolute number or the ratio number — *Iris pumila* L. cannot be divided into geographically well-distinguishable groups or taxa.

Analysis 2/I—Examination the grouping of infraspecific taxa on the basis of the absolute measurement of the vegetative parts (Fig. 5)

Collection B

The aim of this analysis was to examine how, on the basis of infraspecific terms found on the herbarial sheet, the individuals arrange into groups. Supposedly, if individuals with identical names arrange into identical clusters, this will confirm their relatedness and justify the term.

Similarly to the former analyses, well-separating clusters were obtained also here (for example, 11—17—23—33—47—15—48), these, however, were heterogeneous with respect to their terms.

From this we draw the conclusion that

1. either the designations used on the herbarial sheet are not correct,
2. or, on the basis of the measurements of the vegetative parts, the infraspecific taxa designated by the authors cannot be separated by this method;
3. or, the separation of these infraspecific taxa is not justified.

Analysis 2/II — Examination of infraspecific taxon groupings on the basis of ratio numbers obtained from the vegetative part sizes (Fig. 6)

Collection B

In comparison with the preceding analysis, the clusters became considerably re-arranged, but these clusters are, similarly distinguishable fairly well. They also contain individuals of various designation and so they do not confirm the justification of any of the designations, which again indicates one of the three cases enumareted above.

On the dendrogram of the analyses described in detail above, we have obtained clusters well-distinguishable in each of the cases. These clusters, however, do not correspond to each other in the various analyses: the same individuals belong to different groups according to whether we take into consideration the absolute number or carry out the analysis on the basis of the ratio numbers.

The individual clusters are heterogeneous both geographically (by location, base rock, altitude) and taxonomically, i.e. by the taxonomical designations used by the collectors.

By inference it can be stated that, on the basis of the vegetative part sizes or the ratio numbers calculated from them, *Iris pumila* L. in the area examined (in the Carpathian Basin) cannot be classified into homogeneous groups either geographically, or into the current taxonomical classification.

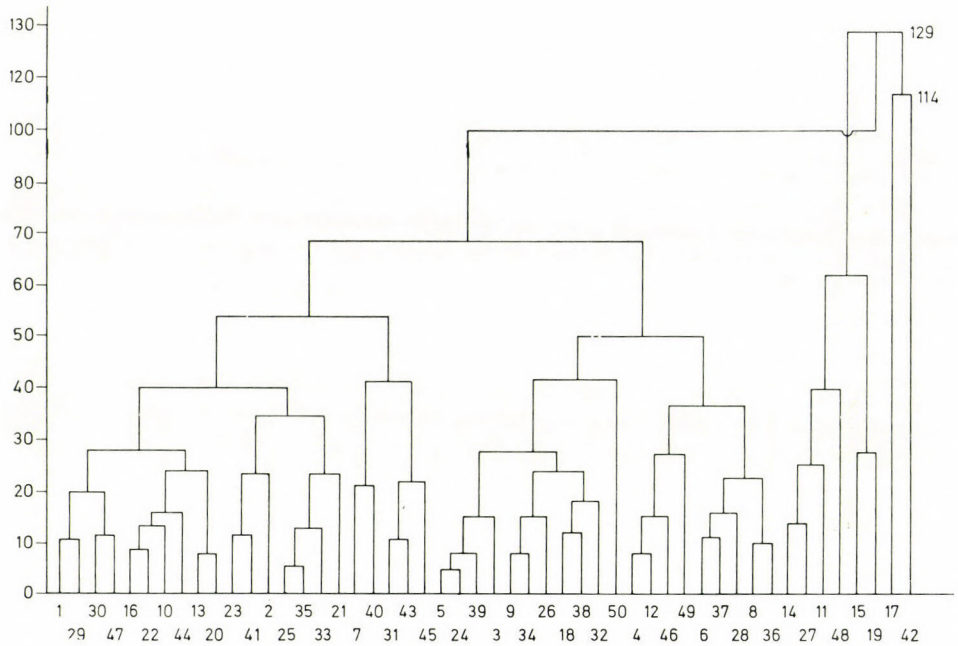


Fig. 6. Analysis 1/II, Collection B and Analysis 2/II, Collection B dendrogram. For symbols see Fig. 5.

Presumably, *Iris pumila* L., on the basis of flower part sizes (or possibly by some other method), classifiable into well-distinguishable geographical units or infraspecific taxa, this, however, will have to be decided be future examinations. In which case we shall have to give up the possibility of unambiguously identifying herbarial specimens.

The analyses described above prove that cluster analysis is applicable for the solution of taxonomical problems. By this means and on the basis of the characteristic properties, the species examined can be classified into groups, or it can be shown whether the groups or clusters, originally considered as homogeneous, are indeed such.

Analysis containing erroneous data (Figs 7 and 8)

In the course of my work, I mistakenly measured in one of the specimens (No. 31, Figs 7 and 8), a leaf-bundle consisting only of leaves and had also run the programme on the basis of these data (absolute numbers and ratio numbers).

On the dendrogram, this specimen remarkably separated itself from the others; it formed an independent cluster, while another specimen obtained from the same locality did not do so.

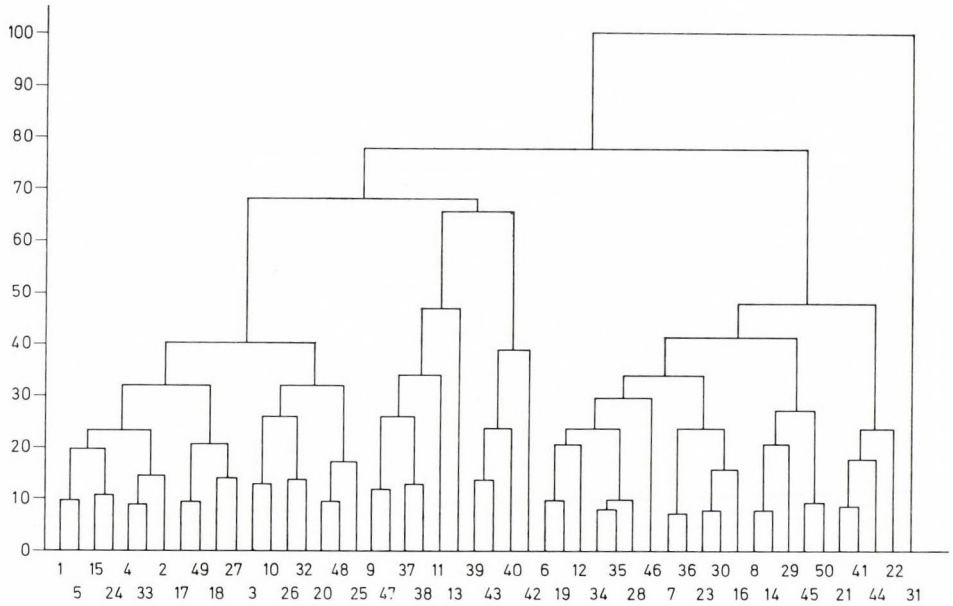


Fig. 7. Dendrogram of an analysis containing erroneous measuring data (absolute numbers). For symbols see Fig. 3.

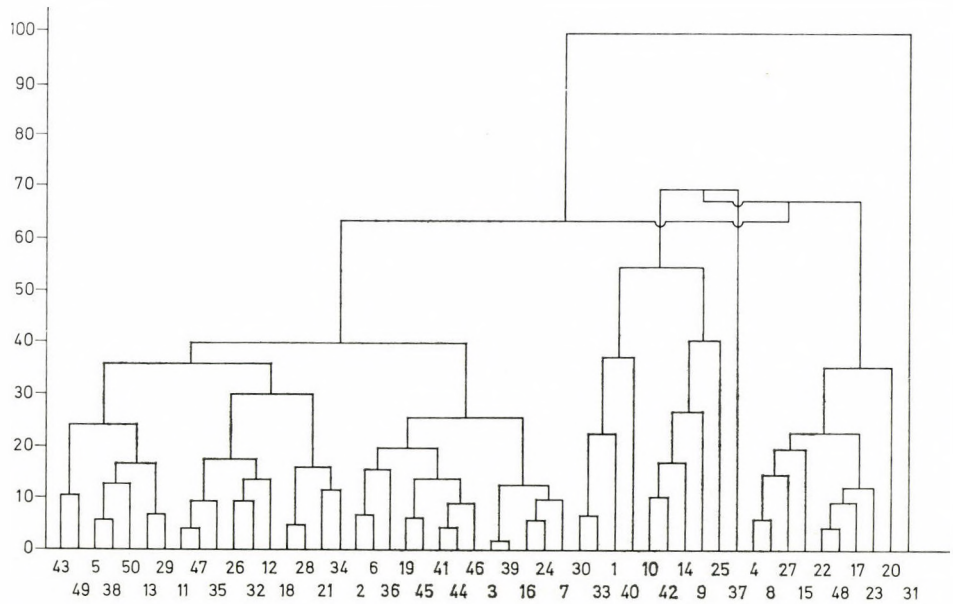


Fig. 8. Dendrogram of an analysis containing erroneous measurement data (ratios). For symbols see Fig. 3.

By re-measuring the first specimen and by running the programme with the newly obtained correct data, I arrived at new dendrograms (Figs 3 and 4) in which this specimen did not separate from the others.

This erroneous measuring was a good occasion to prove that, even on the basis of the vegetative part sizes, the individuals having measurements different from those of the others can be separated (for example, collection A, individuals Nos 31 and 37, Fig. 8; and individual No. 37, Fig. 4). On the other hand, this method was convincing by its very sensitivity, since it immediately signalled the error.

IV. Conclusions

It can be inferred from the analyses that, on the basis of the sizes of the vegetative parts and of the ratio numbers formed from them, *Iris pumila* L. cannot in the area examined (in the Carpathian Basin) be classified into homogeneous groups either geographically or by current taxonomical classifications.

The examinations show that cluster analyses are applicable for taxonomical tests. By this means and on the basis of the characteristic properties, the species examined can be set into groups, or it can be demonstrated whether the groups or clusters originally considered as homogeneous, are actually such.

ACKNOWLEDGEMENTS

I express my thanks to István Précsényi and Zoltán Szőcs, for the discussion of the problems arising during my work and for their extensive help to András Horánszky, for the professional guidance and for the lending of the herbarial material of the department; to Julia Szujkó-Lacza, to Gábor Fekete, and to Tibor Simon, for allowing the herbarial material to be examined.

REFERENCES

Goldstein, R. A.—Grigal, D. F. (1972): Computer programs for the ordination and classification of ecosystems. — Oak Ridge Natn. Lab., Oak Ridge

Goodall, D. W. (1973): Numerical classification. In: Handbook of vegetation science. Part V: Ordination and classification of vegetation. Ed. by Whittaker R. H., Junk, — The Hague, 577—615.

Horánszky, A.—Szőcs, Z. (1972): Die Trennung von Festuca-Populationen mit Hilfe der Diskriminanzanalyse. — Ann. Univ. Scient. Budapest, Sect. B. **15,** 75—81.

Jardine, N.—Sibson, R. (1971): Mathematical taxonomy. — Wiley. London—New York—Sydney—Toronto.

Orloci, L. (1967): An agglomerative method for the classification of plant communities. — J. Ecol. **55,** 193—206.

Sokal, R. R.—Sneath, P. H. A. (1963): Principles of numerical taxonomy. — Freeman San Francisco—London.

Szőcs, Z. (1973): Néhány sokváltozós analízis botanikai alkalmazásáról (On the botanical application of some multi-variate analyses). II. — Bot. Közl. **60,** 29—33.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (3—4), pp. 415—436 (1976)

COMPARATIVE ANALYSIS OF SOME DIVERSITY FUNCTIONS UNDER DIFFERENT CONDITIONS OF SAMPLING IN SANDY MEADOW

By

J. N. NOSEK

DANUBE RESEARCH STATION, HUNGARIAN ACADEMY OF SCIENCES, ALSÓGÖD

(Received July 2, 1976)

As a preliminary, the author outlines the shortcomings of investigations made so far as well as the concept of diversity based on set theory (JUHÁSZ-NAGY, 1973). A review of different diversity and equitability functions and/or indices used in the literature follows.

The investigations were made in a sandy meadow *(Festucetum vaginatae danubiale)* at Vácrátót (near Vác, North Hungary).

Six diversity functions (the SIMPSON-type, the GINI-type, the MCINTOSH-type, the PIE, the corrected — with the species number of the population — and the non-corrected SHANNON-WEAVER-type), and one equitability function (:$D - D_{1\cdot\min.}/D_{1\cdot\max.} - D_{1\cdot\min.}$:) were examined.

Two conditions of sampling were made; (a) the increase of the area of the subsamples by power of two, from 100 cm² to 3200 cm², (b) the transformation of the shape of the subsamples, from a quadrate to a gradually narrower rectangle (side ratios also by power of two, from 1 : 1 to 1 : 32).

No systematic relation could be established in the case of the SIMPSON- and MCINTOSH-type functions and in that of the PIE, either to the increase in area, or to the transformation in shape.

In the case of the GINI-type and the non-corrected SHANNON-WEAVER function, a logarithmic relation was visible with increase in the area. The diversity of the population was always underestimated. Their values were independent of the transformation above 1600 cm².

A hyperbolic relation was shown in the case of the corrected SHANNON-WEAVER function to the area. The diversity of the population was overestimated to 400 cm², and underestimated from 1600 cm². It became independent of the transformation above 800 cm².

The equitability values changed in different ways by the various shapes in relation to the area. There was no systematic relation to the transformation. For the most part, the equitability of the population was overestimated.

The best estimate of the diversity of the population investigated could be made by use of the corrected SHANNON-WEAVER function and the subsample of 1600 cm² and 1 : 32 side ratio.

I. Introduction

The problems of correlations between the species and the number of individuals (GARTHSIDE, 1928; cit. in WILLIAMS, 1964), the species and the abundance, and species and area (WILLIS, 1922: GLEASON, 1922; 1925; all three cit. in AUCLAIR and GOFF, 1971) have already been raised at the start of investigations of biocenoses. These inquiries led to the formation and use of the conception named diversity after WILLIAMS (1944; cit. in WILLIAMS 1964).

The paper discusses the behaviour of some diversity functions on the basis of examinations carried out under various conditions of sampling in a sandy meadow (*Festucetum vaginatae danubiale*).

Before analysing the results, we shall have to survey — even if briefly — the problems related to the concept of diversity and its measuring, the diversity indices and functions that have been in use so far, and the shortcomings of diversity examinations.

II. The posing of the problems

The term diversity is widespread in literature. Several authors have discussed it in various approaches. There are some excellent reviews available (PIANKA, 1966; MCINTOSH, 1967; CANCELA DA FONSECA, 1966, 1969a, 1969b; PEET, 1974), offering a comprehensive picture of the subject and its literature. This abundance in the use of the concept is, however, burdened with grave problems. In most of the cases it implies a confused, uncritical mixture of concepts, definitions, models or methods of measurement (cf. EBERHARDT, 1969). The concept of diversity, in most of the cases, was defined by means of the function which was used for its measurement (cf. PEET, 1974). Since there were a number of various indices or functions suggested for measuring diversity, several definitions have come into existence even though the phenomenon for which they are applied is the same. In many of the cases, the use of the conceptions 'diversity' and 'heterogeneity' is also confused.

Therefore, a concise definition of the concept is needed above everything else. A general and concise definition does exist (JUHÁSZ—NAGY, 1973), but it has not yet gained enough ground in literature. Owing to its significance, it shall be dealt with in detail below.

Most of the diversity indices and functions that have been used so far, and their applications, bear in themselves the heritage of the starting problem (the question of species and number of individuals, and the species and area), that is, they refer only to the species-individuals diversity. This is only a special case of the concept of diversity; by means of the general definition (cf. JUHÁSZ—NAGY 1973), the phenomenon can be examined in a much wider sphere.

The extensive 'diversity' of the diversity indices and functions which are in use results — in addition to the state that the notion is uncleared — in the fact that there is no uniform system of models which would make possible either a uniform approach of the problem of the various synbiological objects, or an examination of its relationship with other synbiological basic phenomena (JUHÁSZ—NAGY, 1972, 1973). Consequently, there are only a few papers discussing the examination of diversity and other synbiological basic phenom-

ena (for example, similarity, preference, etc.) (DÉVAI, HORVÁTH, and JUHÁSZ-NAGY 1972, 1973).

Further researches are needed with regard to the questions of diversity and succession and/or degradation, and to that of the relationship between diversity and stability. In the case of the latter, a special difficulty is the unclarified state characterizing the concept of stability.

There is only one article treating the examination of diversity by means of space processes (DÉVAI, HORVÁTH and JUHÁSZ-NAGY, 1971). The behaviour of diversity as a function of different conditions of sampling has also been discussed only on a very small scale.

The list of shortcomings is by no means complete, but the questions which were mentioned are probably the most essential ones among the numerous problems awaiting an analysis.

III. The concept of diversity and its measuring

Diversity, like similarity, preference, etc. is one of the synbiological basic phenomena (DÉVAI, HORVÁTH and JUHÁSZ-NAGY, 1971). The interpretation of synbiological basic phenomena is not in the scope of the present study, since it can be found in the papers of the authors mentioned above.

What is diversity? The simplest way of interpreting it is to use an intuitive example (JUHÁSZ-NAGY, 1973). Let us take a fictive community, where:

X is the set of individuals, $X = \{x_1, x_2, \ldots x_i, \ldots x_n\}$ and
Y is the set of species, $Y = \{y_1, y_2, \ldots y_k, \ldots y_s\}$

further

$$\sum_{i=1}^{n} x_i = N, \quad \text{and} \quad \sum_{k=1}^{s} y_k = S$$

where N is the total number of individuals, and
S is the total number of species,

Let n_1 be the number of individuals belonging to species y_1, n_2 that of species y_2, ... n_s that of species y_s. Sets $n_1, n_2, \ldots n_s$ are real, disjoint subsets of X:

$$\bigcup_{j=1}^{s} n_j = X \quad \text{and} \quad \bigcap_{j=1}^{s} n_j = \Phi\,, \text{ and also}$$

$$\sum_{j=1}^{s} n_j = N$$

that is, each of the individuals belongs only to one species. Diversity in this community is the greatest if each of the individuals belongs to a separate species, that is, as many species exist as there are individuals. Diversity is the smallest —zero— if each of the individuals belongs to the same species, that is, there occurs one species only.

In other words, diversity is absolutely maximum in the case of

$$\text{(a)} \quad S = N\,, \quad \text{if} \quad S > 1 \quad \text{and} \quad N > 1$$

and it is absolutely minimum —zero— in the case of

$$\text{(b)} \quad S = 1\,, \quad \text{if} \quad N > 1\,.$$

Obviously, diversity can also be different in the case of a given S, $(1 \leq S \leq N)$ depending on the distribution of the individuals among the species, that is, on the relationship

of the separate n_j's to each other. This relationship is called equitability. Evidently, for a fixed S $(1 \leq S \leq N)$, diversity is the greatest if the distribution of the individuals is equal:

$$(c) \quad n_1 = n_2 \ldots = n_S .$$

Diversity is the smallest if, with the exception of one species, one individual belongs to each of the other species and all the remaining other individuals belong to one species:

$$(d) \quad n_1 = N - S + 1 , \quad \text{and} \quad n_j = 1 , \quad (j = 2, 3, \ldots s)$$

These two cases are the two absolute extreme values of equitability (in case (c) the absolute maximal, in case (d) the absolute minimal). These are, at the same time, the two local extreme values of diversity (for a given S, $(1 \leq S \leq N)$, which appear between (a) and (b). It is to be noted that in case (a) the actual, the local minimum and maximum values of diversity are equal, and in that of (b) these values are all zero.

This example is only a special case of diversity, the so-called species-individual diversity. It is easy to infer that the concept can be generalized. By keeping the set of conditions (set operations, extreme values) and by using the term representant in place of individual and category in place of species, we obtain the general interpretation of the concept of diversity. Following from this, S is the number of categories, N is that of the representants. The set of the representants (X) is the collection, the diversity of which undergoes examination (JUHÁSZ-NAGY, 1973).

It follows from the general interpretation that diversity is not only one of the basic phenomena of synbiological systems, but that it can be extended to all such systems where partition can be carried out (cf. the set operations) and frequency distribution can be set up. Then the basic question refers to the nature of the empirical diversity in relation to the theoretically possible maximal diversity.

Obviously, a system can simultaneously have various structures. For example, synbiological systems have topographic, physiognomic, floristic-faunistic, trophic, etc. structures. These exist simultaneously, side by side. One of the various structures is the frequency structure which represents the number of categories and the distribution of the representants in the categories. Diversity as a basic phenomenon reflects this structure.

Diversity, — which can be established and which reflects the frequency structure of a given system — is a result of several effects. In most of the cases it is not easy to disjoint and determine these effects. Therefore, the simple correlation between the diversity and other variables (e.g. abundance, productivity, efficiency, stability, several physical and chemical parameters, etc.) must be treated in a very critical way, and it must not be assumed a simple causal relation.

Synbiological diversity is in a very close relationship with the occupancy problems of statistical mechanics and with the problems of niche segregation (MARGALEF, 1957; DÉVAI, HORVÁTH and JUHÁSZ-NAGY, 1971).

For measuring diversity, a function should be found which satisfies the following conditions—following also from the concept of diversity.

1. Its absolute maximum should be in the case $N = S$, $(S > 1$ and $N > 1)$, its absolute minimum in $S = 1$, $(N > 1)$.

2. If $1 \leq S \leq N$, then for a given S it should assume its maximum value if $n_j = \frac{N}{S}$; while its minimum value when $n_1 = N - S + 1$, and $n_2 = n_3 = \ldots = n_S = 1$.
3. The including of a category containing a zero representant should not change its value, that is, it should be additive:

$$D_{(n_1, n_2, n_3, \ldots n_s)} = D_{(n_1, n_2, n_3, \ldots n_s, 0)}$$

4. It should be a strictly monotonic function, that is, on addition of a category containing however a small but not zero-valued representant, its value should increase.

$$D_{(n_1, n_2, n_3, \ldots n_s)} < D_{(n_1, n_2, n_3, \ldots n_s, n_{s+1})}$$

Several functions can satisfy these conditions, The diversity values calculated on the basis of different functions react differently to the changes in the number of categories or in the evenness of the distribution (cf. PEET, 1974). This problem — along with that of the unifying of the concept — raises the necessity of unifying the function used for measurement. On the basis of examinations so far, the use of functions derived from information theory seems the most suitable, primarily, because it can be adjusted to the other basic phenomena. (JUHÁSZ-NAGY, 1972; PIELOU, 1972; COLWELL-FUTUYMA, 1971; HAEDRICH, 1975).

IV. A short survey of the various indices and functions used for measuring diversity and equitability

IV.1. Diversity indices and functions

While compiling our survey, we took the examples exclusively from the field of species-individual diversity, However, the conclusions drawn from the examples are similarly valid in relation to the generalized diversity concept.

IV.1.1 The number of species as a diversity index

Several of the authors use the concept of diversity as a synonym of the species number (WHITTAKER 1965; MCNAUGHTON, 1967, 1968; SINGH—MISRA, 1969; HURD et al., 1971; HARGER, 1972; BARBOUR-BROWN, 1974, etc.) This is not correct and it is misleading; it is more appropriate in such cases — namely when it is only the number of species considered — to use the term species richness.

IV.1.2. Dominance-diversity curves

In 1965, WHITTAKER suggested the use of curves which he named the dominance-diversity curve for the examination of the structure of community. These curves are in fact logarithmic importance — species sequence curves, where the species are ranked according to decreasing 'importance' on the x axis; the concrete equivalent of 'importance' can be several kinds of variable, for example, biomass, productivity, the number of individuals, etc. He considers net annual primary production as the most suitable one. Similarly REINERS et al. (1971) gave under the name dominance-diversity curve, a curve referring to foliar cover and species sequence.

These curves offer more information on the collection examined, but they still do not correspond to the concept of diversity (cf. III). The use of the term diversity is incorrect and misleading also here. Although their shape may render inferences as to the number of species and to the distribution of the variable examined among the species, their use is cumbersome, especially in comparative studies. The curves are namely to be drawn with respect to each of the collections and then compared with one another. This needs, if we want to choose the correct way, a mathematical-statistical analysis, which involves a circuitous procedure.

IV.1.3. Diversity indices based on the total number of species and individuals

These indices are based on the various ratios between the number of species and individuals. Many kinds of such indices can be created; in the literature mostly the following seven occur:

$d_1 = \frac{S}{N}$ MONK, 1966 (cit. in AUCLAIR—GOFF, 1971)

$d_2 = \frac{S}{\log N}$ GLEASON, 1922 (cit. in AUCLAIR—GOFF, 1971)

$d_3 = \frac{S}{\log T}$ GLEASON, 1922 (cit. in AUCLAIR—GOFF, 1971; T is the total area from where S originates.

$d_4 = \frac{S-1}{\ln N}$ MARGALEF, 1957

$d_5 = \frac{\log S}{\log N}$ MENHINICK, 1964

$d_6 = \frac{S}{\sqrt{N}}$ MENHINICK, 1964

$d_7 = \frac{S}{\frac{N}{S}} = \frac{S^2}{N}$ WILLIS, 1922 (cit. in AUCLAIR—GOFF, 1971)

These ratios are not diversity indices (cf. III), and they have several disadvantages. Above all, infinitely many different S and N can give the same value, since a ratio number can be produced from infinitely many pairs of numbers. Besides, they do not tell us anything about the distribution of the individuals among the species.

IV.1.4. Diversity indices based on species abundance curves

If we illustrate the number of species as a function of the number of individuals belonging to one species, we obtain a discrete frequency distribution. The shape of the distribution will depend on the number of species and on the individuals representing one species. To the diagrams obtained in this way, various known probability distributions can be fitted. In the later phases of analysis, the number of species and the distribution of individuals can be characterized by means of the corresponding parameters of fitted probability distribution.

The first distribution recognized to be well-fitted to certain sampling data was the logarithmic distribution. FISHER, CORBETT and WILLIAMS described it in detail in their paper published in 1943 (cit. in WILLIAMS, 1964). For measuring diversity, they used one of the characteristic parameters of distribution, namely α; the value can be expressed from the total number of species and individuals:

$$S = -\alpha \ln (1 - X)$$
$$N = \alpha X (1 - X)$$

The value α is high if the diversity of the collection examined is great, and it is small if diversity is low.

Beside the logarithmic distribution, other theoretical probability distributions can also be fitted to the data of observation. For certain data, PRESTON (1948, cit. in PIELOU, 1969) found lognormal distribution, while BRIAN (1953) found the negative binomial distribution the most appropriate for fitting. All distributions have their characteristic parameters allowing the production of the function. They can be used as indices of diversity.

These indices also have several disadvantages:
- the characteristic parameters obtained from the different distributions cannot be compared directly even in the case of S and N being of the same magnitude;
- they cannot be applied uniformly enough. None of them can be considered as suitable in a high percentage of the cases;
- the Γ (PEARSON III.)-type functions are flexible enough for errors to be easily committed at fitting, not choosing the right function. But even in the case of a suitable function, a large number of species and individuals is necessary for fitting. They cannot be used reliably in the case of small-sized collections;
- in many of the cases, calculation is lengthy; as in case of several distributions, the data will have to be transformed. For an accurate fitting, the statistical analysis is a requirement;
- finally, the greatest disadvantage is that they cannot be applied in the case when the species abundance curve observed cannot be approximated by any of the theoretical distributions.

IV.1.5. Yule-type diversity index

The frequency distribution of different nouns in samples taken from the works of divers authors was examined by YULE in his work published in 1944 (cit. in WILLIAMS, 1964). The characteristic value suggested by him was modified by WILLIAMS, and named as the YULE-type diversity index.

$$D_Y = 1 - \frac{\sum_{i=1}^{S} n_i(n_i - 1)}{N^2}$$

Its value is great if the diversity is high, and it is small if diversity is low.

IV.1.6. The Simpson-type function

SIMPSON described in 1949 the function which was named by him as the measure of concentration:

$$\lambda = \frac{\sum_{i=1}^{S} n_i(n_i - 1)}{N(N - 1)}$$

The value λ is the reciprocal of diversity, i.e. it is great if the diversity is low and vice versa. The function used for the measuring of diversity is obtained from the following equation:

$$D_S = 1 - \frac{\sum_{i=1}^{S} n_i(n_i - 1)}{N(N - 1)}$$

The value of D_S varies between zero and one. If each of the individuals belongs to one species, then it is zero, and if each of the individuals belongs to a separate species, then it is one.

IV.1.7. The Gini-type function

For the measuring of the heterogeneity of a given collection, GINI suggested in 1912 the function named the mutability index ("un indice di mutabilità") (cit. in LETI, 1965), as

$$D_G = 1 - \sum_{i=1}^{S} p_i^2$$

The probabilities of occurrence appearing in the function (p_i) can be estimated from the relative frequencies:

$$\widehat{p_i} = \frac{n_i}{N} \qquad \widehat{D_G} = 1 - \sum_{i=1}^{S} \frac{n_i^2}{N^2}$$

The value of D_G changes between zero ($S = 1,\ N > 1$) and $1 - \frac{1}{S}$ ($S = N, S > 1, N > 1$).

IV.1.8. The Hurlbert-type probability of interspecific encounter

It is essentially based on the same consideration as the SIMPSON-type measure of concentration, with the only difference that the two individuals chosen random, belong not to the same but to different species (cf. SIMPSON, 1949 and HURLBERT 1971):

$$PIE = \frac{\sum_{i=1}^{S} n_i(N - n_i)}{N(N-1)}$$

Concerning its values, the same statements hold as for D_S.

IV.1.9. The McIntosh-type diversity function

The diversity function suggested by MCINTOSH (1967) is based on linear algebra, on a basis entirely different from those suggested earlier:

$$D_M = \frac{N - \sqrt{\sum_{i=1}^{S} n_i^2}}{N - \sqrt{N}}$$

Its value changes between zero ($S = 1,\ N > 1$) and one ($S = N,\ S > 1,\ N > 1$).

IV.1.10. Diversity functions based on the information theory

Lately functions derived from information theory have been used most widely and their literature is also the largest. Two kinds of function exist, one for finite and one for infinite collections, that is, for discrete and for continuous distributions. BRILLOUIN's formula provides the quantity of information or diversity for finite collections as:

$$H = \frac{K}{N} \log \frac{N!}{n_1!\, n_2! \ldots n_s!}$$

where K is a constant depending on the basis of the logarithmic function.
SHANNON-WEAVER's formula is given for infinite collection:

$$H' = -\sum_{i=1}^{S} p_i \log p_i$$

In the latter, the probabilities of occurence (p_i) can be estimated, according to what has been said above for the GINI-type functions (cf. IV. 1.7), from the relative frequencies (LLOYD et al., 1968; PIELOU, 1966a).

Between the usage of the two kinds of function there is an essential difference of interpretation in synbiological practices. A detailed description and explanation of this can be found in PIELOU's papers (1966a, 1966b, 1969).

IV.2. Equitability indices

In the concept of diversity there are two independent variables, namely the number of species and the distribution of the individuals among the species. The result is that the diversity value of a community of many species but of a very uneven distribution of individuals can be in agreement with that of a community with a small number of species but of an even distribution of individuals. Therefore, diversity must be disjointed to its components. The examination of the values of diversity, of the number of species and of equitability together provides much more information than that of the value of diversity alone. There is no problem with the number of species. For the calculation of the diversity, we have seen a few of the possibilities. For the calculation of equitability there are also several methods described in the literature. It is to be noted that in the case of IV.1.1, IV.1.2 and IV.1.3, equtability cannot be interpreted and therefore no possibility exists for its establishment in values.

IV.2.1. The formulas used most frequently are as follows (HURLBERT, 1971):

$$V' = \frac{D}{D_{l\cdot\max}} \qquad V = \frac{D - D_{l\cdot\min}}{D_{l\cdot\max} - D_{l\cdot\min}}$$

where $D_{l\cdot\min}$ and $D_{l\cdot\max}$ are the local minimum and maximum values of diversity (cf. III), D is the actual value of diversity. V' is identical with PIELOU's formulae J and J' (for BRILLOUIN's and SHANNON-WEAVER's formulae: PIELOU, 1966b, 1969).

IV.2.2. MARGALEF (1957) and PATTEN (1962) used the *redundancy* concept applied in information theory:

$$R = \frac{D_{l\cdot\max} - D}{D_{l\cdot\max} - D_{l\cdot\min}}$$

The following correlation exists between redundancy and the value of V: $R = 1 - V$.

IV.2.3. In the equitability index suggested by LLOYD and GHELARDI (1964), the distribution named as the MACARTHUR-type *broken stick model* (MACARTHUR, 1957) is used as

$$\varepsilon = \frac{S'}{S}$$

where S is the observed number of species. S' is the number of species calculated from the MACARTHUR-type distribution at the actual value of diversity. According to this formula, the distribution is the most even if it is in agreement with that of the model. In reality, a distribution more even than this has already been observed (KRICHER, 1972; HAJDU, personal communication). Besides, in calculating the value of ε, the value of S' is often a fractional number whose interpretation is doubtful.

IV.2.4. The equitability index cited by SHELDON (1969) is formally similar:

$$Q = \frac{S^*}{S}$$

where S is the observed species number. S^* is the number of species corresponding to the even distribution providing the same value of diversity at the same magnitude of N.

$$S^* = e^D$$

where D is the observed diversity value, 'e' is the basis of the natural logarithm.

IV.2.5. FAGER (1972) suggests two possibilities for measuring equitability. One of them (*SD*) is the *standard deviation* of the number of individuals (n_i).

$$SD = \left[\frac{S \sum_{i=1}^{S} n_i^2 - N^2}{S(S-1)} \right]$$

In the other function, termed by him the "number of moves" (*NM*), there are two variables, viz. the number of individuals (n_i) and the ranks belonging to the numbers of individuals (R_i). The largest number of individuals receives rank number 1.

$$NM = \frac{N(S+1)}{2} - \sum_{i=1}^{S} R_i n_i$$

For a better interpretation, he suggests also a scaling, in the same manner as in case of redundancy (cf. IV.2.2).

IV.2.6. HILL (1973) suggests the usage of *the ratios between the various diversity functions* (the functions of SIMPSON and SHANNON-WEAVER) *and the number of species.* These, however, cannot in all cases be interpreted simply (cf. PEET, 1974). The cause of this is hidden in the dual nature of the diversity functions (cf. IV. 2). Since this duality does exist in each of the functions forming the ratios, no direct correlation is obtained with the nature of the distribution.

It is to be noted that in the case of $S = 1$ (cf. (b) in III), equitability cannot be interpreted — there exists no diversity — and in the case of $S = N$ (cf. (a) in III) equitability cannot be computed for the scaled indices (e.g. *V*, *R*, scaled *SD* and *NM*).

In the course of our survey, no detailed description of the various indices and function could be given, owing to lack of space. It was also only in relation to the most essential cases that we made our critical remarks. A detailed discussion or a more elaborate range of critical remarks are to be found in the articles of the authors cited, or in the reviews and summarizing papers (for example, LLOYD and GHELARDI, 1964; MENHINICK, 1964; DICKMAN, 1968; SHELDON 1969; EBERHARDT, 1969; FAGER, 1972; HILL, 1973; DEBENEDICTIS, 1973; ALLAN, 1975; HAMILTON, 1975; DEJONG, 1975, PEET, 1975).

V. The aim of the present paper

In the knowledge of the shortcomings described above, the aim of the present study was to examine species-individual diversity under different conditions of sampling in botanical objects. Further, the comparison and analyses of six diversity functions, viz. of the SIMPSON-type, the GINI-type, the *PIE*, the MCINTOSH-type, the corrected, [with the total number of species of the population, (cf. PIELOU 1966b)], and the uncorrected SHANNON-WEAVER functions, and the equitability values belonging to them, respectively, as well as the choosing of the most suitable one on the basis of sampling.

VI. Material and method

The examinations were carried out in a sandy grassland (*Festucetum vaginatae danubiale*), one of the characteristic communities of the calciferous sandy soil in the area between the Danube and Tisza rivers, near Vácrátót, in July 1975. The size of the basic sampling area was 4.8 × 10 m. In this area 10 species occured, represented by 8493 individuals. For a part of the *Thymus* species, exact identification could not be done — owing to infectedness — therefore, designed as *Thymus* sp., they were treated as belonging to the same species. In patch-forming species (*Festuca vaginata*, *Festuca wagneri*, *Fumana procumbens*, and *Thymus* sp.),

one patch was taken as one individual. The distribution of the individuals as to species was as follows: *Festuca vaginata* 2520, *Festuca wagneri* 101, *Medicago minima* 1699, *Carex stenophylla* 1518, *Thymus sp.* 1506, *Fumana procumbens* 1084, *Centaurea arenaria* 24, *Cynodon dactylon* 23, *Plantago indica* 17, and *Onosma arenaria* 1 individual. The cover of the sampling area was about 65%; the two *Festuca* species represented 25%, the *Thymus sp.* 25%, *Fumana procumbens* 10%, while the other species together also 10%. An accurate map on a scale of 1 : 10 was drawn of the basic sampling area, and all further elaborations were made on its basis, using a slightly modified version of the so called 'Photocomputational Method' (Szőcs, 1977).

During the investigations two conditions of sampling were applied:

1. Increasing the area of the subsamples (within identical shapes) by powers of two, from 100 cm² (100, 200, 400, 800, 1600, and 3200 cm²).

2. The transformation of the shape of the subsample by the elongation of the square into an increasingly narrower rectangle (but of identical areal size), by increasing the longer sides again by powers of two (side ratios; 1 : 1, 1 : 2, 1 : 4, 1 : 8, 1 : 16, and 1 : 32).

The various subsamples were placed on the map randomly, with the aid of a Hewlett-Packard 9820A-type computer, in a repetition of 30 each. A total of 1260 subsamples were analysed. The individuals representing the various species were counted in all subsamples — even those which grew on the edge of the subsample, and even if a larger part of them fell outside the subsample (patch-forming species).

The following uniform designations and symbols are used: S, N, T for the total number of species, of individuals, and the area of the subsample; D_G, D_S, PIE, D_M, H'' and H''_{corr}. for the diversity values calculated on the basis of the Gini, Simpson, Hurlbert, McIntosh, Shannon-Weaver functions (not corrected and corrected). E_G, E_S, E_{PIE}, E_M, $E_{H''}$, $E_{H''_{\text{corr}}}$. are equitability values belonging to the relevant functions. **A**, **B**, **C**, **D**, **E**, and **F** represent the various shapes of the subsamples (**A** is the square with side proportion 1 : 1; **B** is a rectangle with 1 : 2, **C** with 1 : 4, **D** with 1 : 8, **E** with 1 : 16 and **F** with 1 : 32 side proportions). The dash above the various symbols represents the mean of the 30 repetitions performed within identical subsamples. The mean values are at the same time the estimates of the values of the population (4.8 × 10 m basic sampling area).

The functions which served as a basis for the calculations were partly taken from the original articles of the authors (Simpson, 1949; McIntosh, 1967; Hurlbert, 1971); D_G was taken from Leti (1965); H'' and H''_{corr} from Pielou (1966b); the equitability from Hurlbert (1971, the formula denoted by V). The calculations of satatistical analysis were performed after Sváb (1973).

VII. Results and discussion

VII.1. Comparison of the various functions

Despite the apparent differences in definitions and formulas, the Simpson-type function and the *PIE* are identical:

$$D_s = 1 - \frac{\sum n_i(n_i - 1)}{N(N-1)} \equiv \frac{\sum n_i(N - n_i)}{N(N-1)} \equiv PIE$$

$$\frac{N^2 - N - \sum n_i^2 + \sum n_i}{N(N-1)} \equiv \frac{N\sum n_i - \sum n_i^2}{N(N-1)}$$

$$\text{since } \sum n_i = N\,; \quad \frac{N^2 - \sum n_i^2}{N(N-1)} \equiv \frac{N^2 - \sum n_i^2}{N(N-1)}$$

When defining the *PIE*, Hurlbert based his calculations on the number of links in the food web. Each of the links represents the trophic connection of two species and at the same time a prey-predator connection as well. According to him, in communities where the *PIE* value is high, the "sensory ability"

of the predators is more developed than in communities where the *PIE* values are smaller. Thus the *PIE* can be interpreted synbiologically much better than the SIMPSON function.

This statement, in such a generalization, is too simple and in fact not true. In the calculation of the *PIE*, all the pairs consisting of different species do appear. In the food web, however, the number of such pairs is always smaller, for the encounter of the two different species belonging to identical trophic level does not mean the consumption of one of them. In other words, *PIE* always overestimates the probability of the encounters representing the trophic connections, and it does this to different extents depending on the number of species which compose the various trophic levels. Accordingly, there is no reason to prefer *PIE* instead of D_S.

The following correlation exists between D_G and D_S : $D_S = \left(\frac{N}{N-1}\right) D_G$. The difference between the two functions gradually decreases with the increase of N.

The values of H'' and H''_{corr} also approximate each other with the increase of N, within a given collection (PIELOU, 1966a, 1966b).

The equitability values calculated on the basis of D_S and *PIE* are in agreement owing to the identity of the two functions.

The values of E_S and E_G differ from one another in the case of very small numbers of individuals; this difference decreases quickly with the increase of N. The rounding of the results to three decimals in the case of N occuring during the processing of data did not produce any difference. Therefore E_S could be used in place of the two values throughout the calculations.

The equitability values of H'' and H''_{corr} do not differ from each another.

In the last analysis, three equitability values were produced for the six functions, viz. E_S for functions D_S, D_G, and *PIE*; E_M for D_M; and $E_{H''}$ for H'' and H''_{corr}.

VII.2. The values calculated for the basic sampling area

When analysing the results, we considered as population the set of individuals occuring in the whole 4.8 × 10 m area, the diversity of which was estimated by means of the various subsamples. The values of the population related to the divers variables under examination took the following pattern: $S = 10$ (when calculating the value of H''_{corr} we used this value in the correction member); $N = 8493$; $D_G = 0.792$; $D_S = 0.792$; $D_M = 0.550$; $H'' = 1.658$; $H''_{corr} = 1.659$; $E_S = 0.880$; $E_M = 0.795$, and $E_{H''} = 0.719$. These values also illustrate what has been said above with regard to the approximation of the relevant functions to one another (cf. VII.1).

VII.3. Changes in the function of the area

There existed a linear relation between $\overline{N}$ and T with respect to each of the subsamples (Table 1). The correlation coefficients and the linear regression coefficients are given in Table 5. The very high correlation coefficients at the same time indicate that we were right when in the case of the patch-forming species we considered one patch as one individual.

A logarithmic relation was found between the area and $\overline{S}$, $\overline{D}_G$ and $\overline{H}''$. When increasing the area, $\overline{S}$ did not flatten in the case of any of the subsample shapes (see Table 1; Fig. 1). In the case of the $\overline{D}_G$ curves a flattening could be observed; in the case of shape **A** after 1600 cm²; in shapes **B**, **C**, **D** and **F** after 800 cm², while in shape **E** after 400 cm² (Table 2, Fig. 2). The curve of $\overline{H}''$ flattened after 1600 cm² in the case of each shape (Table 3, Fig. 3). The correlation and linear regression coefficient values between the variables mentioned and the logarithm of the area are given in Table 7.

A hyperbolic relation was found between $\overline{H}''_{\text{corr}}$ and T. Flattening of the curves ensued in each of the shapes after 1600 cm² (Table 3; Fig. 4). The correlation and linear regression coefficient values between the reciprocal of the area and $\overline{H}''_{\text{corr}}$ are given in Table 9.

The values of $\overline{D}_S$ and $\overline{D}_M$ did not show a systematic relation with the increase in the area (Table 2).

The three equitability values were very near to each other and behaved similarly as a function of the increase in the area, within the various shapes

Table 1

The value of $\overline{S}$ and $\overline{N}$ as a function of the shape and size of the subsample

Shape \ Area (cm²)	100	200	400	800	1600	3200
A	2.233	3.067	3.567	4.433	5.200	5.600
	3.567	4.833	7.733	15.300	32.433	60.933
B	2.533	3.167	3.633	4.600	5.267	5.800
	3.500	5.267	8.600	17.330	32.567	62.833
C	2.367	3.167	3.767	4.433	5.167	5.600
	3.667	6.300	11.200	17.533	33.933	58.233
D	2.600	3.300	3.967	4.800	4.900	5.733
	3.800	6.933	11.000	19.467	35.767	65.200
E	2.867	3.667	4.233	4.733	5.467	5.600
	4.833	8.100	13.333	22.000	41.667	71.267
F	3.367	4.167	4.667	5.033	5.633	5.600
	6.233	9.300	14.600	26.700	40.500	73.667

(Upper values belonging to a given shape and area represent $\overline{S}$, the lower ones $\overline{N}$)

Table 2

The values of $\overline{D}_G$, D_S and $\overline{D}_M$ as a function of the shape and size of the subsample

Shape \ Area (cm²)	100	200	400	800	1600	3200
A	0.396	0.570	0.614	0.652	0.732	0.754
	0.543	0.721	0.737	0.703	0.757	0.767
	0.498	0.657	0.646	0.569	0.591	0.580
B	0.457	0.560	0.631	0.686	0.727	0.750
	0.663	0.698	0.746	0.733	0.751	0.763
	0.631	0.636	0.648	0.594	0.585	0.576
C	0.484	0.557	0.641	0.693	0.736	0.742
	0.838	0.668	0.729	0.738	0.760	0.756
	0.636	0.592	0.613	0.596	0.592	0.569
D	0.502	0.613	0.683	0.722	0.716	0.748
	0.712	0.728	0.772	0.764	0.739	0.760
	0.666	0.638	0.661	0.620	0.570	0.572
E	0.554	0.643	0.701	0.712	0.735	0.761
	0.724	0.744	0.776	0.748	0.754	0.772
	0.650	0.642	0.656	0.597	0.579	0.583
F	0.630	0.699	0.711	0.735	0.747	0.758
	0.783	0.794	0.775	0.765	0.767	0.769
	0.701	0.689	0.650	0.608	0.596	0.578

(Upper values are $\overline{D}_G$, middle values $\overline{D}_S$, lower values $\overline{D}_M$, belonging to the given shape and area)

Table 3

The value of $\overline{H}$ and $\overline{H}''_{corr}$ as a function the shape and size of the subsamples

Shape \ Area (cm²)	100	200	400	800	1600	3200
A	0.649	0.984	1.106	1.246	1.442	1.516
	2.435	2.284	1.951	1.578	1.593	1.593
B	0.765	0.989	1.129	1.323	1.436	1.515
	2.313	2.274	1.790	1.610	1.584	1.591
C	0.765	0.978	1.157	1.315	1.454	1.498
	2.133	2.049	1.685	1.594	1.594	1.578
D	0.823	1.067	1.245	1.417	1.391	1.529
	2.256	1.801	1.745	1.647	1.530	1.602
E	0.930	1.153	1.308	1.380	1.465	1.529
	2.216	1.736	1.736	1.597	1.579	1.595
F	1.094	1.305	1.383	1.441	1.518	1.519
	1.936	1.825	1.758	1.621	1.635	1.583

(Upper values are $\overline{H}''$, lower values $\overline{H}''_{corr.}$, belonging to the given shape and area)

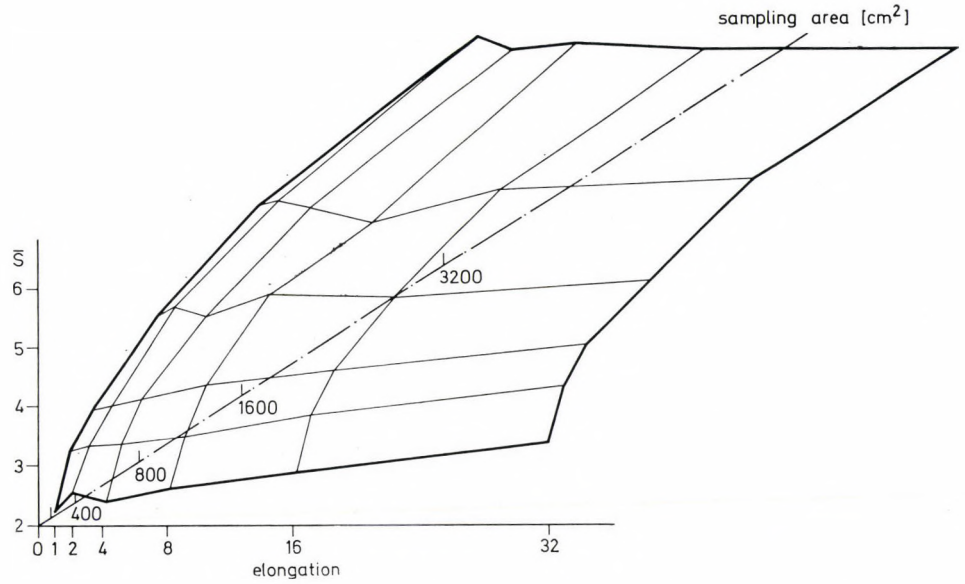


Fig. 1. S plotted against sampling area (x axis) and elongation (x axis, there is the ratio of the longer and shorter sides of the sampling unit)

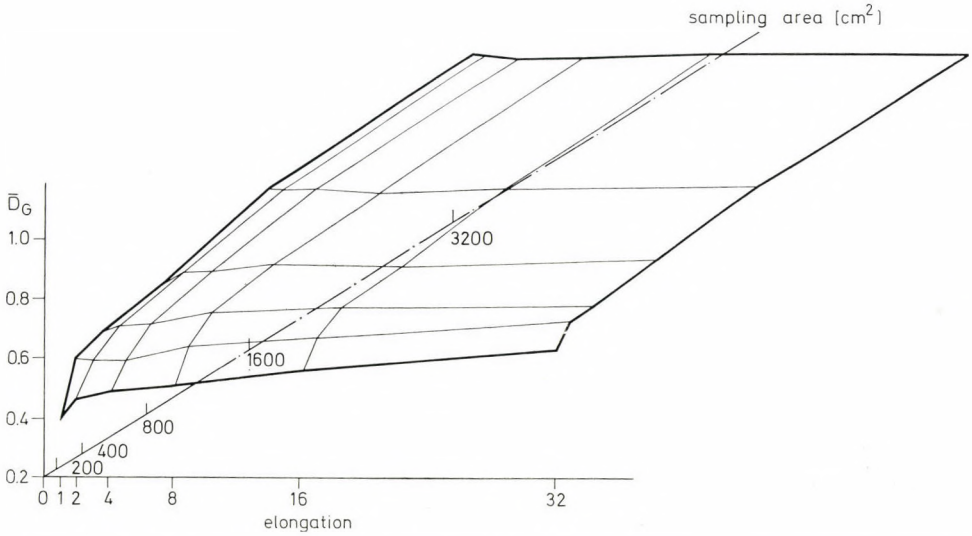


Fig. 2. $\bar{D}_G$ plotted against sampling area (x axis) and elongation (x axis, scaled in the same manner, as in fig. 1)

Table 4

The value of $\overline{E}_S$, $\overline{E}_M$ and $\overline{E}_{H''}$, as a function of the shape and size of the subsamples

Shape \ Area (cm²)	100	200	400	800	1600	3200
A	0.474	0.738	0.665	0.682	0.869	0.902
	0.469	0.729	0.645	0.649	0.826	0.859
	0.464	0.719	0.636	0.632	0.815	0.851
B	0.386	0.638	0.727	0.772	0.859	0.889
	0.377	0.628	0.705	0.738	0.814	0.840
	0.367	0.618	0.693	0.730	0.800	0.828
C	0.513	0.775	0.807	0.821	0.883	0.884
	0.511	0.757	0.778	0.789	0.841	0.835
	0.509	0.740	0.777	0.878	0.835	0.835
D	0.567	0.775	0.797	0.857	0.868	0.889
	0.564	0.761	0.776	0.821	0.827	0.843
	0.562	0.754	0.758	0.809	0.822	0.847
E	0.819	0.693	0.849	0.851	0.870	0.917
	0.808	0.673	0.829	0.813	0.822	0.879
	0.804	0.658	0.813	0.810	0.808	0.866
F	0.666	0.763	0.816	0.886	0.880	0.911
	0.652	0.742	0.787	0.850	0.836	0.871
	0.643	0.721	0.792	0.836	0.830	0.857

(Upper values are $\overline{E}_S$, middle values $\overline{E}_M$, and lower values $\overline{E}_{H''}$, belonging to the given shape and area)

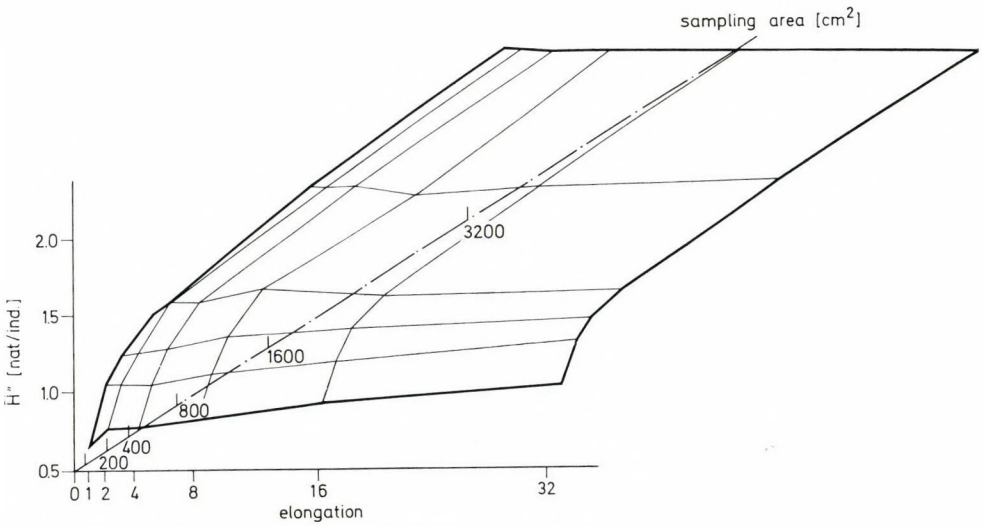


Fig. 3. $\overline{H}''$ plotted against sampling area (*z* axis) and elongation (*x* axis, scaled in the same manner, as in Fig. 1)

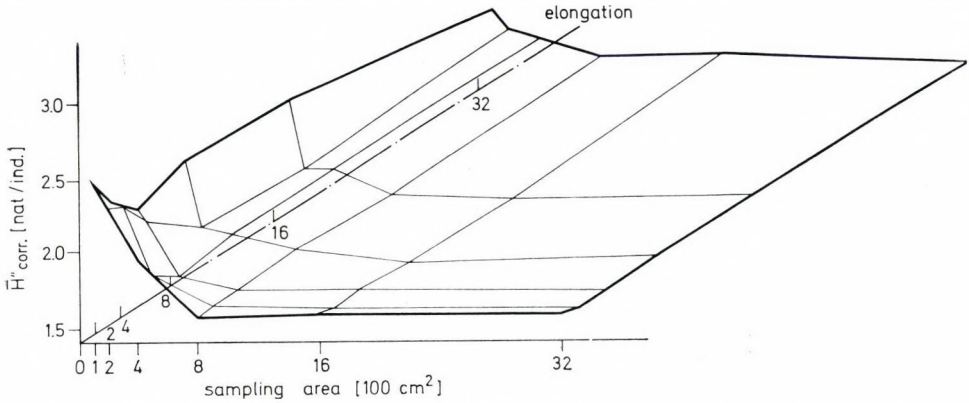


Fig. 4. $H''_{corr.}$ **plotted against sampling area (*x* axis) and elongation (*z* axis, scaled in the same manner, as the *x* axis in Fig. 1)**

Table 5

The correlation and linear regression coefficient values between $\overline{N}$ *(y variable) and area (x variable) of the various subsamples*

Shape	*r*	$\frac{T}{\overline{N}}$	
		a	*b*
A	0.999^{+++}	1.022	0.019^{+++}
B	1.000^{+++}	1.554	0.019^{+++}
C	0.997^{+++}	3.399	0.018^{+++}
D	0.999^{+++}	3.048	0.020^{+++}
E	0.998^{+++}	4.404	0.021^{+++}
F	0.997^{+++}	6.012	0.021^{+++}

Level of significance: $^{+++} = 0.1\%$

Table 6

The values of correlation and linear regression coefficients between $\overline{N}$ *(y variable) and elongation (x variable) for the various area sizes* (In elongation, the proportion between the longer and the shorter sizes were considered as variable)

Area (cm^2)	*r*	Side proportion $\overline{N}$	
		a	*b*
100	0.993^{+++}	3.315	0.091^{+++}
200	0.948^{++}	5.363	0.136^{++}
400	0.897^{+}	8.983	0.200^{+}
800	0.984^{+++}	16.232	0.337^{+++}
1600	0.858^{+}	33.085	0.291^{+}
3200	0.901^{+}	60.559	0.457^{+}

Levels of significance: $^{+} = 5\%$, $^{++} = 1\%$, $^{+++} = 0.1\%$

Table 7

The values of the correlation and linear regression coefficients between $\overline{S}$, $\overline{D}_G$, $\overline{H}''$ (y variables) and the logarithm of the area (x variable) for the various shapes of subsamples

Shape	log T								
	$\overline{S}$			$\overline{D}_G$			$\overline{H}''$		
	r	a	b	r	a	b	r	a	b
A	0.996^{+++}	−2.280	2.287^{+++}	0.953^{++}	0.016	0.219^{++}	0.980^{+++}	−0.371	0.555^{+++}
B	0.996^{+++}	−1.999	2.240^{+++}	0.973^{++}	0.107	0.192^{++}	0.988^{+++}	−0.188	0.502^{+++}
C	0.998^{+++}	−1.881	2.167^{+++}	0.970^{++}	0.151	0.178^{++}	0.984^{+++}	−0.177	0.498^{+++}
D	0.989^{+++}	−1.348	2.021^{+++}	0.917^{+}	0.252	0.150^{+}	0.956^{++}	0.024	0.444^{++}
E	0.988^{+++}	−0.684	1.857^{+++}	0.941^{++}	0.339	0.125^{++}	0.968^{++}	0.247	0.380^{++}
F	0.971^{++}	0.583	1.512^{++}	0.931^{++}	0.502	0.077^{++}	0.937^{++}	0.639	0.268^{++}

Levels of significance: $^{+}$ = 5%, $^{++}$ = 1%, $^{+++}$ = 0.1%

Table 8

The values of correlation and linear regression coefficients between $\overline{E}_S$, $\overline{E}_M$, and $\overline{E}_{H,}$, (y variables) and the logarithm of the area (x variable) for the various shapes of subsamples

Shape	log T								
	$\overline{E}_S$			$\overline{E}_M$			$\overline{E}_{H''}$		
	r	a	b	r	a	b	r	a	b
Y	0.878^{+}	0.055	0.242^{+}	0.840^{+}	0.110	0.213^{+}	0.840	0.106	0.211^{+}
B	0.938^{++}	−0.130	0.306^{++}	0.922^{++}	−0.076	0.276^{++}	0.921^{++}	−0.082	0.274^{++}
C	0.850^{+}	0.208	0.208^{+}	0.822^{+}	0.260	0.179^{+}	0.808	0.236	0.191
D	0.878^{+}	0.283	0.185^{+}	0.846^{+}	0.337	0.155^{+}	0.872^{+}	0.320	0.159^{+}
E	0.720	0.566	0.097	0.613	0.597	0.075	0.577	0.595	0.072
F	0.946^{++}	0.390	0.156^{++}	0.938^{++}	0.413	0.137^{++}	0.935^{++}	0.403	0.137^{++}

Levels of significance: $^{+}$ = 5%, $^{++}$ = 1%

Table 9

The values of correlation and linear regression coefficients between $\overline{H}''_{corr}$ (y variable) and the reciprocal of the area (x variable) for the various shapes of subsamples

Shape	$\frac{1}{T}$ $\overline{H}''_{corr.}$		
	r	a	b
A	0.932^{++}	1.591	96.005^{++}
B	0.917^{+}	1.581	85.142^{+}
C	0.937^{++}	1.557	64.059^{++}
D	0.979^{+++}	1.538	68.765^{+++}
E	0.966^{++}	1.536	63.215^{++}
F	0.955^{++}	1.610	35.452^{++}

Levels of significance: $^{+} = 5\%$, $^{++} = 1\%$, $^{+++} = 0.1\%$

Table 10

Percentage deviation between the values of the population and the function values observed at the beginning of the flattening phase

Shape	H''	$H''_{corr.}$	D_G	E_S	E_M	$E_{H''}$
A	−13.03	−3.98	− 7.70	−1.25	3.90	13.35
B	−13.39	−4.52	−13.38	−2.38	2.38	11.26
C	−12.30	−3.92	−12.50	−6.71	−0.75	22.11
D	−16.10	−7.77	− 8.83	−2.61	3.27	12.52
E	−11.64	−4.82	−11.49	−3.52	3.90	13.07
F	− 8.44	−1.45	− 7.19	0.68	6.91	16.27

(Negative values represent underestimations of the values of population, positive values are overestimations)

(Table 4). A logarithmic relation could be detected in shapes **B** and **F**; in the case of **C**, **D** and **A** the relation was logarithmic in nature but with a worse correlation than in the case of the preceding ones, In shape **E**, no simple function relation could be detected. The coefficients are given in Table 8.

VII. 4. Changes in the function of elongation

Within an identical size of the area, $\overline{N}$ changed linearly also by elongation, in each of the area sizes, but to a much smaller extent than in the case of area change (cf. Tables 1 and 6).

The values of $\bar{S}$, $\bar{D}_G$ and $\bar{H}''$ increased within an area size by the elongation, but the increase in the gradually increasing areas was of a gradually smaller extent. The curves were increasingly flattening. $\bar{S}$ after 800 cm², $\bar{D}_G$ and $\bar{H}''$ after 1600 cm² became independent of the elongation, with some fluctuation they produced a horizontal (Tables 1 and 2, Figs 2 and 3).

The value of $\bar{H}''_{corr}$ behaved similarly, with the difference, however, that it showed a decrease instead of an increase by the elongation, and it became independent after 800 cm² (Table 3, Fig. 4). $\bar{D}_S$, $\bar{D}_M$ and the three equitabilities did not show a systematic change by the elongation; it could notwithstanding be stated that the range of the values decreased with the gradually increasing areas (Tables 2 and 4).

In the case of the functions showing a systematic relation with the increase in area ($\bar{D}_G$, H'' and $\bar{H}''_{corr}$ for each of the shapes, and $\bar{E}_S$ $\bar{E}_G$ $\bar{E}_{H''}$ for shapes **A**, **B**, **C**, **D** and **F**) the diversity and equitability values of the population can be estimated from the beginning of the flattening phase. The percentage difference between the values measured in this area size and those of the population is given in Table 10.

Summing up the results of the examinations, it can be stated that the best estimation was attained by the application of $\bar{H}''_{corr}$ in the case of the subsample 1600 cm² in area and 1 : 32 in side proportion. The smallest percentage deviation between the observed and the actual values in the case of $\bar{H}''$ and $\bar{D}_G$ was produced also in this subsample, although the difference was greater than that in $\bar{H}''_{corr}$. Each of the observed diversity values underestimated the value of the population.

Among the equitabilities, $\bar{E}_S$ with the exception of one shape **F** underestimated, $\bar{E}_M$ with the exception of one shape **C** overestimated, and $\bar{E}_{H''}$ for all shapes overestimated the equitability value of the population.

ACKNOWLEDGEMENTS

I should like to express my thanks to Dr P. Juhász-Nagy and Dr I. Précsényi, for having directed my attention to this problem and who also provided assitance in the elaboration of this paper, further, to Dr B. Zólyomi, academician, director of the Botanical Research, Institute of the Hungarian Academy of Sciences, for making it possible for me to carry out part of the investigations and also for the use of the computer of the Institute.

REFERENCES

Allan, J. D. (1975): Components of diversity. Oecologia **18,** 359—367.

Auclair, A. N.—Goff, F. G. (1971): Diversity relations of upland forests in the Western Great Lakes area. Amer. Nat. **105,** 499—528.

Barbour, C. D.—Brown, J. H. (1974): Fish species diversity in lakes. Amer. Nat. **108,** 473—489.

Bazzaz, F. A. (1975): Plant species diversity in old-field successional ecosystems in Southern Illinois. Ecology **56,** 485—488.

Brian, M. V. (1953): Species frequencies in random samples from animal populations. J. Anim. Ecol. **22,** 57—64.

CANCELA DA FONSECA, J. P. (1966): Théorie de l'information et diversité spécifique. Bull. Mus. Hist. Nat. Paris **38,** 961—968.

CANCELA DA FONSECA, J. P. (1969a): L'outil statistique en biologie du sol V. — Indices de diversité spécifique. Rev. Écol. Biol. Sol. **6,** 1—30.

CANCELA DA FONSECA, J. P. (1969b): L'outil statistique en biologie du sol VI. — Théorie de l'information et diversité spécifique. Rev. Écol. Biol. Sol. **6,** 533—555.

COLWELL, R. K.—FUTUYMA, D. J. (1971): On the measurement of niche breadth and overlap. Ecology **52,** 567—576.

DEBENEDICTIS, P. A.(1973): On the correlation between certain diversity indices. Amer. Nat. **107,** 295—302.

DEJONG, T. M. (1975): A comparison of three diversity indices based on their components of richness and evenness. Oikos **26,** 222—228.

DÉVAI, I.—HORVÁTH, K.—JUHÁSZ-NAGY, P. (1971): Some problems of model-building in synbiology. Part 1. Spatial diversity process of the binary type in a simple situation. Ann. Univ. Sci. Budap. Sect. Biol. **13,** 19—32.

DICKMAN, M. (1968): Some indices of diversity. Ecology **49,** 1191—1193.

EBERHARDT, L. L. (1969): Some aspects of species diveisity models. Ecology **50,** 503—505.

FAGER, E. W. (1972): Diversity: a sampling study. Amer. Nat. **106,** 293—310.

HAEDRICH, R. L. (1975): Diversity and overlap as measures of environmental quality. Water. Res. **9,** 945—952.

HAMILTON, M. A. (1975): Indexes of diversity and redundancy. J. Water Poll. Centr. Fed. **47,** 630—632.

HARGER, R. (1972): Relative consumer species diversity with respect to producer diversity and net productivity. Science **176,** 544—545.

HILL, M. O. (1973): Diversity and eveness: a unifying notation and its consequences. Ecology **54,** 427—432.

HURD, L. E.—MELLINGER, M. V.—WOLF, L. L.—MCNAUGHTON, S. J. (1971): Stability and diversity at three trophic levels in terrestrial successional ecosystems. Science **173,** 1134—1136.

HURLBERT, S. H. (1971): The nonconcept of species diversity: a critique and alternative parameters. Ecology **52,** 577—586.

JUHÁSZ-NAGY, P. (1972): Elemi preferenciális folyamatok információelméleti modellezése szünbotanikai objektumokon (Information theoretical modelling of elementary preference processes in synbotanical objects). Candidate thesis, MS.) Kandidátusi értekezés, kézirat, Budapest, 1—252 pp.

JUHÁSZ-NAGY, P. (1973): A növényzet szerkezetvizsgálata: új modellek: elemi beskálázás a florális diverzitás szerint (The structure of vegetation: new models, Part 2. Elementary scaling and floral diversity). Bot. Közlem. **60,** 35—41.

KRICHER, J. C. (1972): Bird species diversity: the effect of species-richness and equitability on the diversity index. Ecology **53,** 278—282.

LETI, G. (1965): Sull'entropia, su un indice del Gini e su altre misure dell'eterogeneità di un colletivo. Metron **24,** 332—378.

LLOYD, M.—GHELARDI, R. J. (1964): A table for calculating the "equitability" component of species diversity. J. Anim. Ecol. **33,** 217—225.

LLOYD, M.—ZAR, J. H.—KARR, J. R. (1968): On the calculation of information-theoretical measures of diversity. Amer. Midl. Nat. **79,** 257—272.

MACARTHUR, R. H. (1957): On the relative abundance of bird species. Proc. Nat Acad. Sci. U. S. **43,** 293—295.

MARGALEF, R. (1957): La teoria de la informacion en ecologia. Mem. Real. Acad. Cien. Artes **32,** 373—449.

MCINTOSH, R. P. (1967): An index of diversity and the relation of certain concepts to diversity. Ecology **48,** 392—404.

MCNAUGHTON, S. J. (1967): Relationships among functional properties of Californian grassland. Nature **216,** 168—169.

MCNAUGHTON, S. J. (1968): Structure and function in Californian grasslands. Ecology **49,** 962—972.

MENHINICK, E. F. (1964): A comparison of some species-individuals diversity indices applied to samples of field insects. Ecology **45,** 859—861.

MORRISON, R. G.—YARRANTON, G. A. (1973): Diversity, richness and evenness during a primary sand dune succession at Grand Bend, Ontario. Can. J. Bot. **51,** 2401—2411.

PATTEN, B. C. (1962): Species diversity in net phytoplankton of Raritan Bay. J. Mar. Res. **20,** 57—75.

PEET, R. K. (1974): The measurement of species diversity. Ann. Rev. Ecol. Syst. **5,** 285—307.

PEET, R. K. (1975): Relative diversity indices. Ecology **56,** 496—498.
PIANKA, E. R. (1966): Latitudinal gradients in species diversity: a review of concepts. Amer. Nat. **100,** 33—46.
PIELOU, E. C. (1966a): SHANNON's formula as a measure of species diversity: its use and misuse. Amer. Nat. **100,** 463—465.
PIELOU, E. C. (1966b): The measurements of diversity in different types of biological collections. J. Theor. Biol. **13,** 131—144.
PIELOU, E. C. (1966c): Species diversity and pattern diversity in the study of ecological succession. J. Theor. Biol. **10,** 370—383.
PIELOU, E. C. (1969): An introduction to mathematical ecology. WILEY-Sons, New York. 286 pp.
PIELOU, E. C. (1972): Niche width and niche overlap: a method for measuring them. Ecology **53,** 687—692.
REINERS, W. A.—WORLEY, I. A.—LAWRENCE, D. B. (1971): Plant species diversity in a chronosequence at Glacier Bay, Alaska, Ecology **52,** 55—69.
SHELDON, A. L. (1969): Equitability indices: dependence on the species count. Ecology **50,** 466—467.
SIMPSON, E. H. (1949): Measurement of diversity. Nature **163,** 688.
SINGH, J. S.—MISYA, R. (1969): Diversity, dominance, stability and net production in the grassland at Varanasi, India. Can. J. Bot. **47,** 425—427.
SVÁB, J. (1973): Biometriai módszerek a kutatásban. 2. Kiadás, Mezőgazdasági Kiadó, Budapest. 517 pp. (Biometric methods in research) 2nd ed. Agricultural Publishers.
SZŐCS, Z. (1977): Új típusú, számítógép-orientált módszerek a vegetáció szerkezetének elemzésére (New types of computer-oriented methods for analysing the structure of vegetation. Candidate thesis, MS.) Kandidátusi értekezés, kézirat, Vácrátót.
TRAMER, E. J. (1969): Bird species diversity: components of SHANNON's formula. Ecology **50,** 927—929.
WHITTAKER, R. H. (1965): Dominance and diversity in land plant communities. Science **147,** 250—260.
WILLIAMS, C. B. (1964): Patterns in the balance of nature and related problems in quantitative ecology. Acad. Press London—New York, 324 pp.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (3—4), pp. 437—448 (1976)

RHODOBRYUM ONTARIENSE (KINDB.) KINDB. IN CENTRAL EUROPE

By

S. ORBÁN and T. PÓCS

DEPARTMENT OF BOTANY, HO SI MINH TEACHERS' COLLEGE, EGER, HUNGARY

(Received November 24, 1976)

The distribution of *Rhodobryum ontariense* (Kindb.) Kindb. is discussed in Central Europe and in the Carpathian Basin, based on the herbarium material of the Hungarian Natural History Museum. *R. ontariense* from 9 countries is newly reported, all within the broad-leaved deciduous forest zones, from calcareous soils.

Z. IWATSUKI and T. KOPONEN (1972), have reestablished the very good distinction between *R. roseum* and *R. ontariense*, in their comprehensive paper on the temperate species related to *R. roseum*. Examining the material of several great herbaria, they have shown the distribution of both species and established that most of the material collected in North America (excepting a few records from the pacific coast) belong to *R. ontariense*. Both species are widespread in Asia, but *R. ontariense* seems more thermophilous and distributed at lower altitudes and latitudes, than *R. roseum*. On the basis of their studies in Europe, *R. roseum* is widespread and *R. ontariense* appears to be rare and disjunct, recognized only from very few localities in the Caucasus, the Pyreneans, and in Southern Scandinavia (Öland). They suggest (page 16) that more European "*Rhodobryum roseum*" material should be studied to obtain a full picture of the distribution of *R. ontariense*.

In October, 1976, T. PÓCS, accompanied by his students and by Mrs. Deisi REYES MONTOYA from Cuba, led a study trip in the Bükk Mts., northern Hungary, where he found, on the shady limestone rocks of a broad-leaved deciduous forest (*Mercuriali-Tilietum*) at the SE foot of Mt. Odorvár (300 m altitude), patches of a *Rhodobryum* which reminded him of the description of *R. ontariense* as given by IWATSUKI and KOPONEN. A more careful study proved that the specimen represents very typically the above species.

Encouraged by this discovery, the authors studied the *Rhodobryum roseum* material, counting more than 300 specimens, in the Botanical Department of the Hungarian Natural History Museum (BP), the HAUSSKNECHT Herbarium, Jena (JE), and the relatively small material of the Eger College Herbarium (EGR). The study resulted in the interesting experience that true *R. roseum* is quite rare in the Carpathian Basin, especially in Hungary, being

restricted to spruce forests, bogs, alder fringes and montane *Nardus* sward on acidic soil. On the other hand, *R. ontariense* is widespread, especially on limestone and dolomite in the broad-leaved deciduous forests of the Hungarian Upland, but occurs also on the calcareous sand dunes of the lowlands. It appears to be common also in the broad-leaved forest zones of the neighbouring countries, in Czechoslovakia, in Soviet Carpatho-Ukraine, and it occurs even

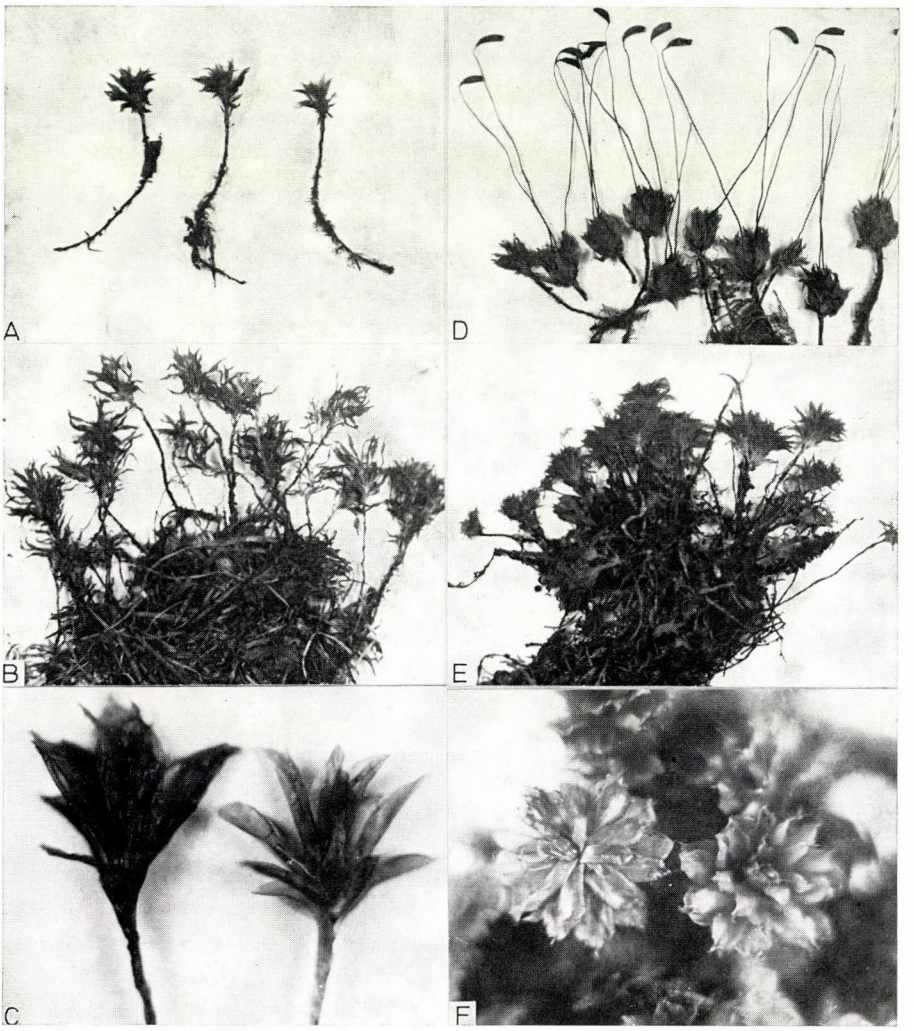


Fig. 1. Specimens of *Rhodobryum roseum* (A—C) and of *Rhodobryum ontariense* (D—F) from the Carpathian Basin. A: NE-Hungarian Highlands, Sátor Mts 118862. B: SW-Hungary, Nagykanizsa-Sormás 118804. C: W-Hungary, Kám, 118802. D: Yugoslavia, Deliblat, Flamunda 63699. E: NE-Hungarian Highlands, Tornai Karszt 118863. F: SW-Hungarian Highlands, Bakony Mts. 118835

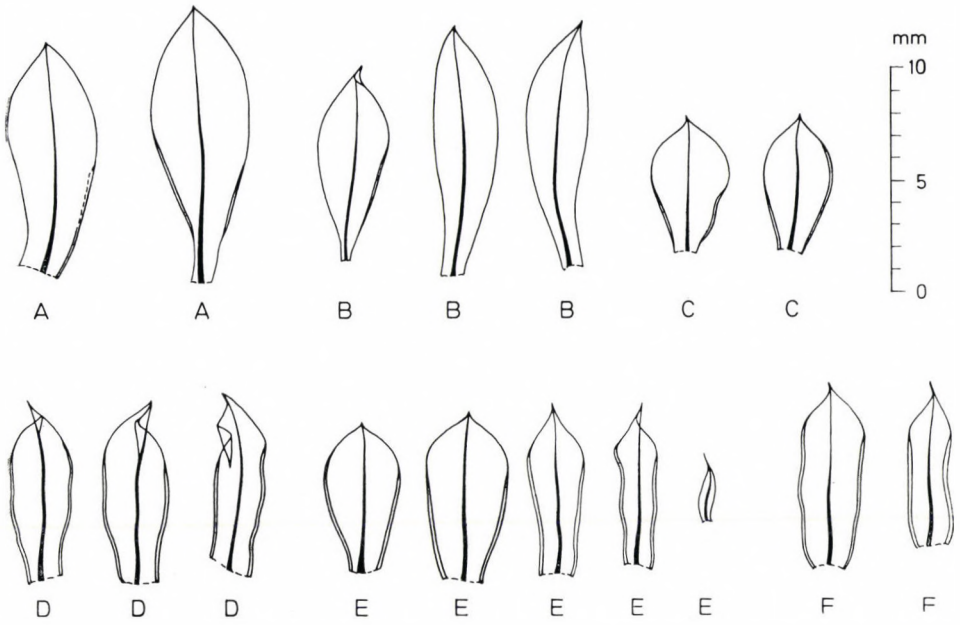


Fig. 2. Leaves of *Rhodobryum roseum* (A—C) and of *Rhodobryum ontariense* (D—F). A: Western Hungary, Szőce, 58513. B: Western Hungary: Kám, 118802. C: Slovakia, Velka Fatra, 118785. D: SW-Hungarian Highlands, Gerecse Mts. E: Western Hungary, Sopron, 118798. F: Balaton Highland, Mt. Szt. György, 7801

in Yugoslavia, Italy, Switzerland, Austria, Southern Germany, Eastern France, and in Belgium.

In the revision of the European *Rhodobryum* material we used all characters enumerated in the paper of IWATSUKI and KOPONEN (1972: 4—12). We found it invariably easy to distinguish the two species by the combination of the characters. In a very few cases, one or antoher character was not typical, but even in these cases the other characters gave a correct identification. (See the Figures 1—4).

The characters of *R. ontariense* are: the number of comal leaves much more than 20, their shape obovate, cuneiform, with strongly revolute margins, their costa percurrent to excurrent (especially those of the perichaetial leaves), and the costa at lower portion contains a large stereid band just below the dorsal epiderm not separated from it by another cell layer. The leaf apex, when moist, is usually widely acute, with an angle of 90—120°. The leaves, when dry, are shrunken and often twisted and thus turn upward.

On the other hand, *R. roseum* has usually less than 20 comal leaves, they are spathulate and more narrowed at their base, with weakly revoluted margin, their costa not reaching the apex, except in the perichaetial leaves. The costa at lower portion contains a small, more centrally situated stereid band separated from the dorsal epidermis by at least one layer of cells. The leaf

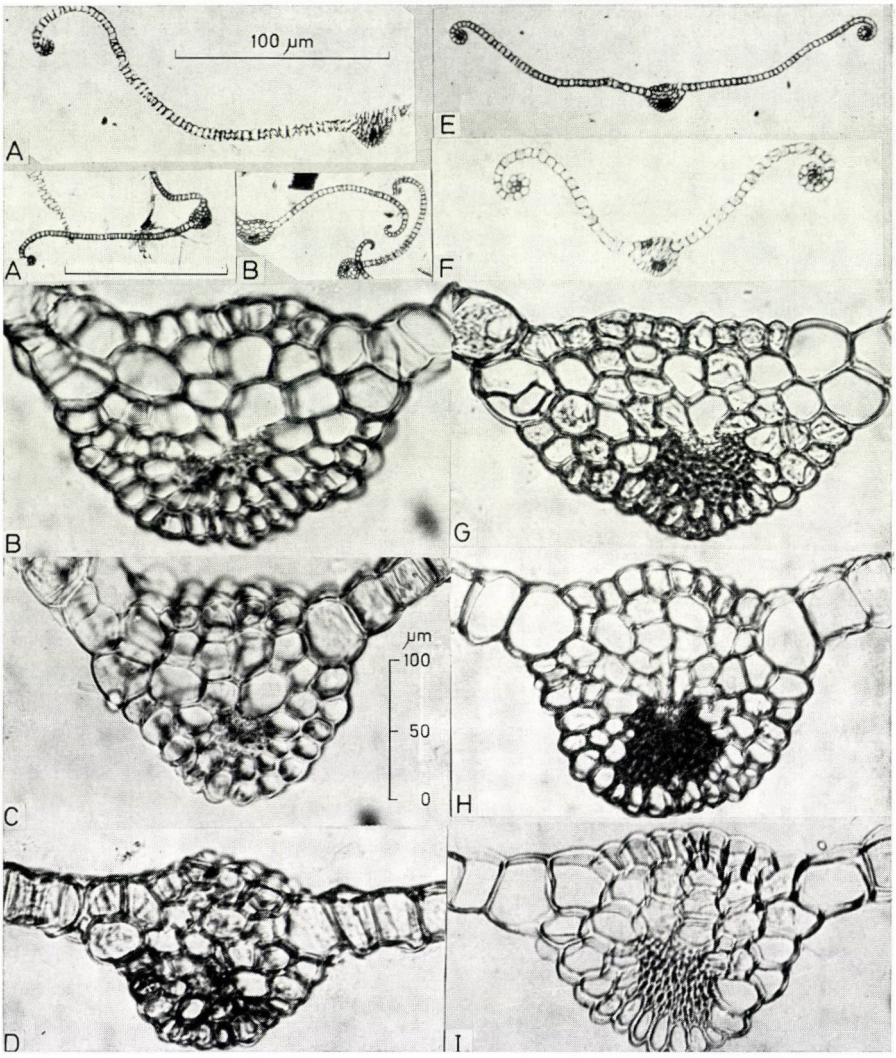


Fig. 3. Transversal sections of *Rhodobryum roseum* (A—D) and of *Rhodobryum ontariense* (E—I) leaves and costae. A and D: NE-Hungarian Highlands, Sátor Mts. 118862. B: Slovakia, Velka Fatra, 118785. C: Western Hungary, Kám, 118802. E and H: NE-Hungarian Highlands, Bükk-Mts. 118845. F: NE-Hungarian Highlands, Tornai-Karszt, 118863. G: Foothills of Bükk-Mts. near Miskolc—Diósgyőr, 8707. I: Tornai-Karszt, Rakaca, 118855

apex, when moist, is acute, with an angle of 65—100°. The leaves, when dry, are less shrunken, more spread.

As far as the distribution of the two species in Central Europe is concerned, *Rhodobryum roseum*, common in the northern coniferous and mixed forests, appears, when going southwards, to be more and more rare, restricted to relict hygrophilous habitats in the warm temperate, deciduous broad-leaved forest

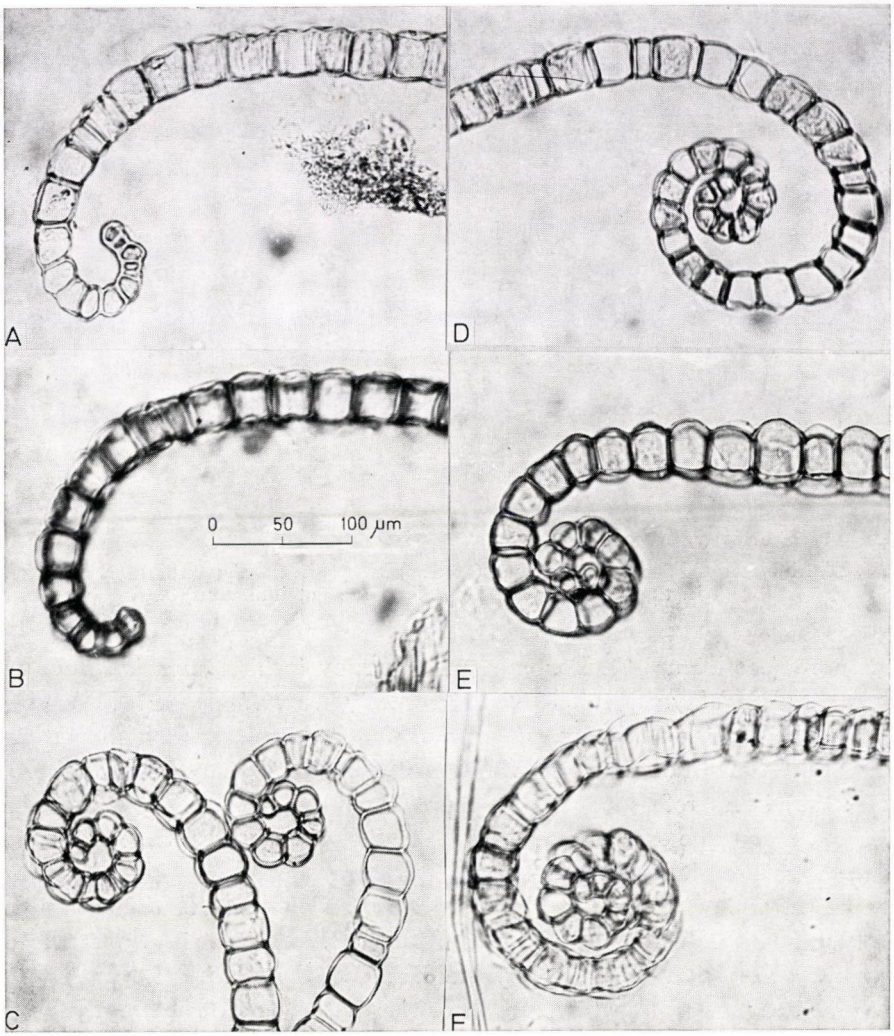


Fig. 4. Transversal sections of *Rhodobryum roseum* (A—B) and *Rhodobryum ontariense* (C—F) leaf borders. A: NE-Hungarian Highlands, Sátor Mts. 118862. B: Slovakia, Velka Fatra, 118785. C: NE-Hungarian Highlands, Tornai-Karszt, Rakaca, 118855. D: Foothills of Bükk-Mts. 7807. E: NE-Hungarian Highlands, Bükk-Mts. 118845. F: Bükk-Mts. 118854

zone. On the other hand, *Rhodobryum ontariense* seems widespread in the same zone, occuring especially on shady or half-shady limestone or on other basic rocks in broad-leaved forests.

In the Alps and in the Carpathians the same zonation can be observed according to altitudes, coinciding well with the same observation made by IWATSUKI and KOPONEN in Japan. *R. ontariense*, together with the former data is known already from 12 European countries and should be expected

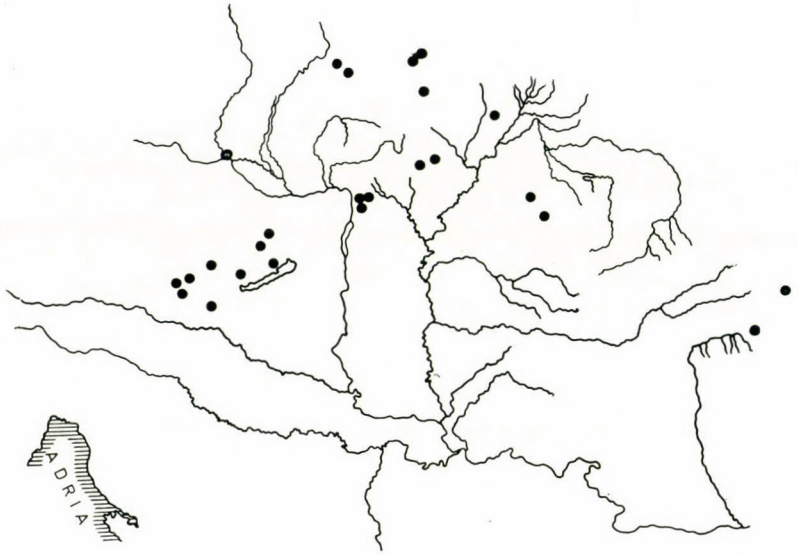


Fig. 5. Distribution of *Rhodobryum roseum* (Hedw.) Limpr. in the Carpathian Basin (localities in the Alps and in the Balcan are not indicated)

from more (see Figure 7). For example, PETROV in his Bulgarian moss flora illustrates a *Rhodobryum*, which is most probably *R. ontariense* (1975: 301, Fig. 1). It should be common in other places of Yugoslavia too, and should be found in the limestone mountains of Southern Poland, although in KUC's work (1964 : 130) is no reference to its occurrence on limestone in the Cracowian Jura Mts. It is to be expected also from the Swiss Jura, as in the neighbouring mountains, where it is known.

In the followings, we give the distribution of both *Rhodobryum* species in the Carpathian Basin and the distribution of *R. ontariense* in Central Europe, based on our revision of the material of BP, JE and EGR (see the maps of the figs. 5—7). In most cases, when not otherwise stated, the specimens are deposited in the Herbarium of the Hungarian Natural History Museum (BP), and the number given is the inventary number of the specimens. We would like to express our gratitude to Mr. L. VAJDA, curator of the *Bryophytes* in the Hungarian Natural History Museum, for the loan of the rich *Rhodobryum* material, and towards Dr. K. MEYER, curator of the HAUSSKNECHT Herbarium, who gave us opportunity to study their RHODOBRYUM materials in Jena. The enumeration follows the regional numbers of ORBÁN—DEBRECZY: Moosarealgeographische Studien aus dem Gebiet der Karpathen und Karpathenbecken (1973).

In a summary of the distribution and ecology of the *Rhodobryum* species in the Carpathian Basin, it can be stated, that the true *Rhodobryum roseum* is acidiphilous-neutrophilous, living in spruce and elder forests, near springs,

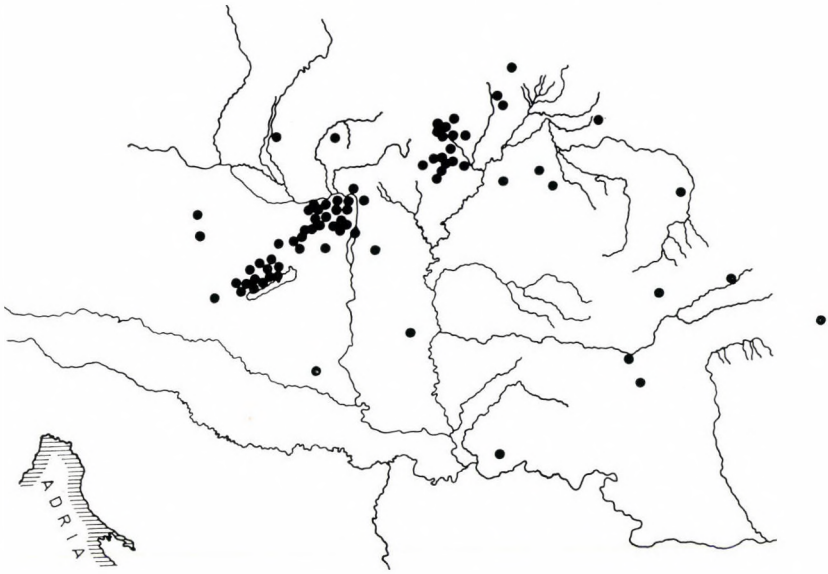


Fig. 6. Distribution of *Rhodobryum ontariense* (Kindb.) Kindb. in the Carpathian Basin (localities in the Alps and in the Balcan are not indicated)

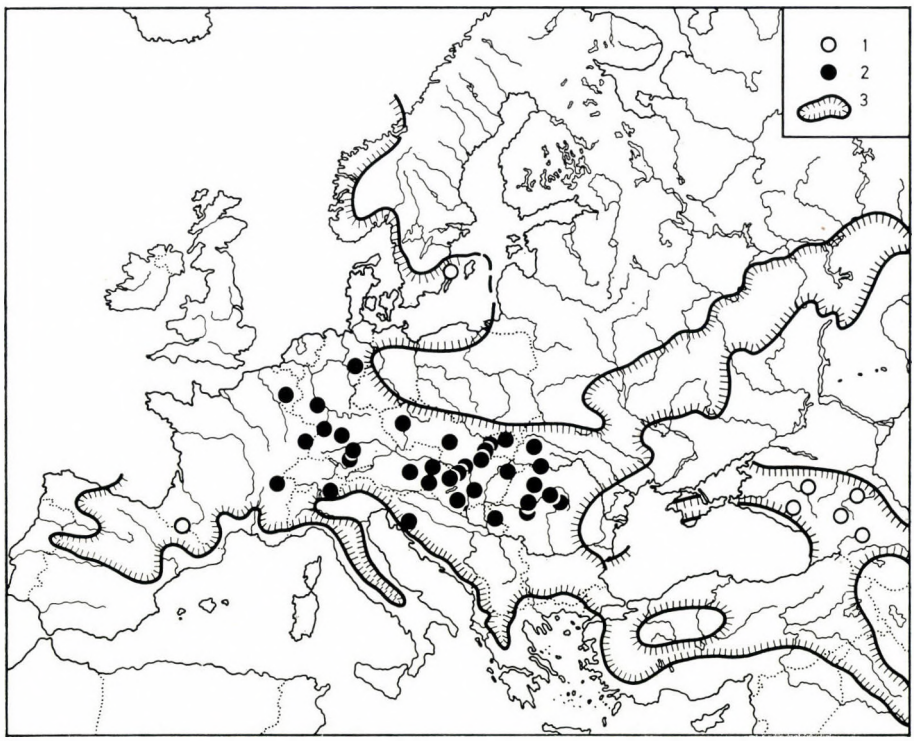


Fig. 7. The European distribution of *Rhodobryum ontariense* (Kindb.) Kindb. 1: Localities published by IWATSUKI and KOPONEN (1972). 2: new localities. 3: boundary of the broad-leaved, deciduous forest zones, including forest steppes. The data obtained from HAUSSKNECHT Herbarium (JE) are not included.

in bogs and in *Nardus* swards. Its lowermost occurrence in the elder fringes of Nagykanizsa and Uzsa and in the Gödöllő Hills and on the acidic sand dunes of the Nyirség in the NE part of the Hungarian Lowlands are parallel with the occurrence of several boreal elements of a relic character in the Hungarian flora (e.g. *Dryopteris cristata, Cicuta virosa, Comarum palustre*, etc.).

On the other hand, *Rhodobryum ontariense* is more thermo- and basiphilous. It is widespread and common in the Hungarian Highlands and also occurs at lower altitudes in the Carpathians in Slovakia, USSR and in Romania, mostly on limestone, sometimes on basaltic, andesitic or on dolomitic rocks in mesophilous broad-leaved forests, as *Orno-Quercetum, Corno-Quercetum, Fago-Ornetum, Mercuriali-Tilietum, Tilio-Fraxinetum, Seslerio-Fagetum, Phyllitidi-Aceretum*, and sometimes on free, yet shaded rock faces. In the lowland areas, it occurs on calcareous sand in the sand-steppe forests (*Junipero-Populetum, Convallario-Quercetum*). In other parts of Central Europe, as in Bohemia, Austria, Southern Germany, France and in Belgium, *R. ontariense* is restricted to shaded limestone rocks in broad-leaved forests.

Rhodobryum roseum (Hedw.) Limpr.

Hungary

XXXI. *Északi-Középhegység: Gödöllői-Dombvidék:* Máriabesnyő, 200 m, 1925, coll. Boros, 118835; Isaszeg, 1910, coll. Szurák, 7786; Babat prope Gödöllő, 1952, coll. Siroki, 118843; Lit.: Szepesfalvi 1942 : 1.
Bükkalja: Szarvaskő, 250 m, 1950, coll. Boros, 118844.
Sátor Mts.: Kemence-patak prope Kishuta, 200 m, 1953, coll. Boros, 118862; Lit.: Boros—Vajda 1955 : 158.

XXXIII. *Bükk Mts.:* Nagymező prope Szilvásvárad et Répáshuta, 200 m, 7—770 m, 1951, coll. Boros, 118840, 118842, Vajda EGR.

XXXIV. *Dunántúli-Középhegység: Bakony Mts.:* Sédpatak prope Pápasalamon, 1955, coll. Csapody, 39094; vall. rivi Lepence prope Uzsa, 200 m, 1953, coll. Boros, 118820; prope Uzsapuszta, 200 m, 1949, coll. Boros, 118817. Vajda EGR.
Balatonfelvidék: inter Aszófő et Balatonszőllős, 1956, coll. Felföldy, 118815.
Keszthely Mts.: mt. Bányafő prope Rezi, 250 m, 1952, coll. Boros, 118814.

XXXV. *Nagy-Alföld: Nyírség:* Gutpuszta prope Nyírmártonfalva, 150 m, 1924, coll. Boros, 118791; in silva Bagoméri-erdő prope Bagamér, 130 m, 1927, coll. Boros; lit.: Boros 1924 : 80.

XXXVI. *Alpokalja: Őrség—Vasi-hegyhát:* prope Zsida, 250 m, 1930, coll. Boros, 118801; sub pag. Szőce, 210 m, 1954, coll. Pócs et Gelencsér 58513, EGR; prope Szakonyfalu 1959, coll. Vajda, 63290; prope Kám, 1958, coll. Vajda, 118802; Lit.: Latzel 1941: 239.

XXXVII. *Zalai-Dombság:* inter Nagykanizsa et Sormás, 150 m, 1953, coll. Károlyi, 118804, EGR.

Czechoslovakia

I. *Kiskárpátok — Malé Karpaty:* Pozsony (Bratislava), coll. Bäumler, 7825, 7827. Lit.: Bäumler 1884: 96.

IV. *Tatra Mts. — Tatry: Belanské Tatry*, coll. Hazslinszky, 7820; *Vysoké Tatry:* Tatranska Lomnicá, 800—1000 m, 1963, coll. Boros, 118787.

VII. *Fatra Mts. — Fatry: Velká Fatra:* mt. Kutnikov kopec prope Lubochna, 6—700 m, 1965, coll. Boros, 118785;
Malá Fatra: Belsky potok, 800 m, 1934, coll. Pilous, 118784. Pilous: Bryotheca Cechoslovenica No. 9; Lit.: Šmarda-Vanek 1955 : 26.

IX. *Slovakia Centr.:* Dobšiná, 880 m, 1953, Šmarda, 118783; Crypt. Cechosl. Exs. No. 347.

Romania

XVII. *Harghita Mts.:* Büdösfürdő prope Csikszentimre, 1200 m, 1970, coll. BOROS, 118781, EGR., VAJDA, EGR.

XVIII. *Háromszéki-medence:* Rétyi-Nyir prope Réty, 1941, coll. BOROS, 118779.

Rhodobryum ontariense (Kindb.) Kindb.

Hungary

XXXI. *Északi-Középhegység: Börzsöny Mts.:* Zebegény, 1951, coll. VAJDA, 7817; Lit.: BOROS—VAJDA 1952 : 62; mt. Naszály prope Vác, 1970, coll. VAJDA 75631; *Bükkalja:* Diósgyőr, coll. HAZSLINSZKY, 7807; Lit.: HAZSLINSZKY 1885 : 183. Szarvaskő, 1950, coll. VAJDA, EGR.

Sátor Mts.: Nagypatak prope Gönc, 1952, VAJDA, 7813; EGR. mt. Magoska prope Mogyoróska, 1951, coll. VAJDA, 7816, EGR. Lit.: VAJDA 1969 : 183.

XXXII. *Tornai-Karszt:* prope Jósvafő, 250 m, 1952, coll. BOROS, 118865; mt. Mezna prope Jósvafő, 300 m, 1952, coll. BOROS, 118867; rivi Kecső prope Jósvafő, 300 m, 1936, coll. BOROS, 118863; mt. Nagyoldal prope Jósvafő, 500 m, 1948, coll. BOROS, 118861; mt. Királyhegy prope Rakaca, 2—250 m, 1957, coll. BOROS, 118855.

XXXIII. *Bükk Mts.:* Szárazvölgy prope Ómassa, 500 m, 1950, coll. BOROS 1952, 118847; Felsősebes-völgy prope Ómassa, 550—650 m, coll. BOROS, 118854; Leány-völgy prope Nagyvisnyó, 6—700 m, 1950, coll. BOROS, 118852; mt. Vöröskő prope Ómassa, 1951, coll. VAJDA, 7804; mt. Borovnyik prope Répáshuta, 600 m, 1957, coll. BOROS, 118857; mt. Borostyánkő ad Pazsag prope Répáshuta, 530 m, 1957, BOROS, 118859; mt. Ördögoldal prope Mályinka, 850 m, coll. BOROS, 118845; Nagymező prope Répáshuta, 770 m, 1951, coll. BOROS, 118842; Kismező prope Jávorkút, 740 m, 1952, coll. BOROS, 118846; coll. VAJDA 7808; Nagymező prope Jávorkút, 770 m, 1952, coll. BOROS, 118849; mt. Odorvár supra Cserépfalu, 300 m, 16, Oct. 1976, PÓCS, EGR.

XXXIV. *Dunántúli-Középhegység: Pilis-Budai Mts.:* Mt. Kálvária prope Pesthidegkút, 1943, coll. VAJDA, EGR; mt. Zamár prope Esztergom, 200 m, 1952, coll. BOROS, VAJDA, 118836, EGR; mt. Csucs prope Csobánka, 300 m, 1946, coll. BOROS, 118837, 1943, coll. VAJDA, EGR; mt. Kecskehegy prope Budakeszi, 200 m, 1941, coll. ZÓLYOMI, 118838; mt. Csillebérc prope Budaörs, 250 m, 1944, coll. VAJDA, EGR; Bükköspatak prope Szentendre, 1908, coll. SZURÁK, 7789; Lit.: Szepesfalvi 1942 : 1; mt. Kiskevély prope Csobánka, 1968, coll. VAJDA, 73825; mt. Sashegy prope Budapest, 1936, coll. VAJDA, EGR.

Gerecse Mts.: mt. Gorba-hegy prope Tardos, 300 m, 1941, coll. BOROS, 118846 mt. Csúcsos-hegy prope Bánhida, 3—350 m, 1938, coll. BOROS, 118847; mt. Sárosi-kő prope Bajna, 320 m, 1948, coll. BOROS, 118849, Vajda, EGR; mt. Peskő prope Tarján, 400 m, 1948, coll. BOROS, 118850, VAJDA, EGR; mt. Öregnyulas prope Bajna, 2—250 m, 1949, coll. BOROS, 118851; mt. Nagysomló prope Dunaszentmiklós, 350—420 m, 1937, coll. BOROS, 118833; mt. Öregkő prope Bajót, 3—375 m, 1936, coll. BOROS, 118834.

Vértes Mts.: mt. Reál prope Pusztakápolna, 3—400 m, 1936, coll. BOROS, 118840; mt. Lóállás prope Csákvár, 2—300 m, 1937, coll. BOROS, 118837; Kőlikvölgy supra Csákvár, 300 m, 1947, coll. BOROS, 118844; Balogvölgy supra Csákvár, 250 m, 1947, coll. BOROS, 118839; mt. Várhegy prope Csókakő, 350—400 m, 1948, coll. BOROS, 118842, VAJDA, EGR; Köves-völgy prope Csákberény, 400 m, 1937, coll. BOROS, 118843; Pap-irtás prope Csákberény, 400 m, 1936, coll. BOROS, 118843; Csákberény 1936, coll. VAJDA, EGR; Galya-szurdok, 200 m, 1965, coll. BOROS, 118828, coll. VAJDA, 71003.

Velencei Mts.: vall. Hurka prope Sukoró, 200 m, 1938, coll. BOROS, 118826.

Bakony Mts.: mt. Baglyashegy prope Inota, 2—300 m, 1954, coll. BOROS, 118829; vall. Gerence prope Bakonybél, 350 m, 1954, coll. BOROS, 118830; mt. Kisbükktető prope Márkó, 400 m, 1967, coll. BOROS, 118835; mt. Kőrishegy prope Bakonybél, 350—400 m, 1937, coll. BOROS, 118832; mt. Baglyashegy prope Csór, 1954, coll. VAJDA, 26909; mt. Mecsek prope Szentgál, 400 m, 1940, coll. BOROS, 118833; vall. Ördögárok prope Bakonyoszlop, 3—400 m, 1938, coll. BOROS, 118834; mt. Kerteskő prope Bakonybél, 350 m, 1937, coll. BOROS, 118831; Hársasvölgy prope Tapolca, 1959, coll. VAJDA, 62552; Tapolcafő, 1953, coll. TALLÓS, 118836; mt. Baloghegy prope Bánd, 1965, coll. VAJDA, 71004.

Balatonfelvidék: mt. Szarkádi-tető prope Tihany, 170 m, 1957, coll. BOROS, 118823; mt. Tamáshegy prope Balatonfüred, 2—300 m, 1926, coll. BOROS, 118824; mt. Alsó, Szarkád prope Tihany, 1956, coll. FELFÖLDY, 118809; vall. Malomvölgy prope Felsőörs

200 m, 1957, coll. Boros, 118822; mt. Cserhegy prope Tihany, 1957, coll. Felföldy, 118825; Aszófői-völgy prope Aszófő, 1949, Felföldy, 118811, 1955, coll. Vajda, 42488; mt. Óvár prope Tihany, 1951, coll. Zsolt, 118813; prope Akali, 1953, coll. Vajda, 26274.

Tapolcai szigethegyek: Szentgyörgyhegy ad Tapolca, 1927, coll. Szurák, 7801; Lit.: Latzel 1933 : 169; mt. Csobánc prope Gyulakeszi, 300 m, 1954, coll. Boros, 118819; mt. Csobánc prope Diszel, 3—370 m, 1959, coll. Boros, 118823; Lit.: Boros—Vajda 1955 : 158; mt. Alsótátika prope Zalaszántó, 300 m, 1955, coll. Boros, 118806; mt. Tátika prope Zalaszántó, 250—300 m, 1956, coll. Boros, 118807, Vajda, 56907.

Keszthelyi Mts.: prope Gyenesidás, 200 m, 1950, coll. Boros, 118816; mt. Csókakő prope Cserszegtomaj, 250 m, 1963, coll. Boros, 118808.

XXXV. *Nagy-Alföld: Dunavidék:* ins. Csepel prope Soroksár, 100 m, 1919, coll. Boros, 118792; Lit.: Boros 1924 : 80.

Duna—Tisza-köze: Ásotthalom, 1955, coll. Bodrogközy, 118788, 118790; Csévharaszt, 1976, coll. Simon, in Herb. Simon.

Nyírség: Bátorliget prope Nyírbátor, 150 m, 1922, coll. Boros, 118793; Lit.: Boros 1924 : 80; Nagyerdő prope Nyírbakta, 1933, coll. Máthé, 118794; prope Büdszentmihály, 1939, Igmándy, 118795; Lit.: Boros 1932 : 36, Soó 1942 : 50.

XXXVI. *Alpokalja: Soproni Mts.:* Szárhalmi-erdő prope Sopron, 1953, coll. Vajda, 25492; Vancsura 118797, EGR.

Kőszegi Mts.: Kőszeg, 440 m, 1932, coll. Visnya, 118797.

XXXVII. *Zalai-Dombság:* Csácsbozsok, 1948, coll. Visnya, 118799.

XXXVIII. *Villányi Mts.:* mt. Harsányi-hegy prope Nagyharsány, 2—400 m, 1925, coll. Boros, 118803; Lit.: Latzel 1934 : 179.

Czechoslovakia

Karlstein, auf Felsblöcken am Waldwege nach Sct. Ivan, 400 m, 1898, coll. Bauer, 82612, 118769; Bauer: Bryotheca Bohemica No. 38.

VI. *Inovec-Tribec Mts.:* Skalice, 1861, coll. Holuby, 82613, 7829.

X. *Slovenské Rudohorie:* Bakabánya (Pukanec), 1897, coll. Kupčok. 7831.

XII. *Slanské pohorie:* Eperjes (Prešov), coll. Hazslinszky; Lit.: Hazslinszky 1855 : 771, 1857 : 7.

XXXII. *Juhoslovenské Kras:* vall. Vinkely prope Barka (Borka), 700 m, 1941, coll. Boros, 118853.

Soviet Union

XIII. *Szinyák Mts.:* Csernekhegy ad Munkács (Mukačevo), 150 m, 1926, coll. Margittai, 7824.

Romania

XVI. *Ţibles Mts.:* fluvii Lápos infra Erdőszállás (Selniţa), 300 m, 1943, coll. Boros, 118777; Lit.: Boros 1943 : 144.

XVIII. *Perşani Mts.:* rivi Vargyas prope Homoródalmás (Homorod-Almaş), 6—700 m, 1942, coll. Boros, 118778; Lit.: Boros 1942 : 145.

XXIII. *Şureani Mts.:* Crivadia, 1972. coll. Orbán, 90113.

XXIX. *Metaliferi Mts.:* Deva, 1895, Péterfi, 7834; Lit.: Péterfi 1896: 11.

XXX. *Erdélyi Medencék:* Torda (Turda), 1916, coll. Péterfi, 118780; Hosszúaszó (Langenthal, Hususau), 1867, coll. Barth, 42279; Barth: Bryoth. transs. No. 20.

Yugoslavia

XXXV. *Deliblato*, 1901, coll. Bernátsky, 63699; Lit.: Pavletić 1955 : 318. Croatia (Modrus-Fiume), in silvis vallis Vinodol ad lac. Velo Polje supra portum Novi, solo calc., 50 m, 1926, coll. Kümmerle, 7838.

Italy

Varese, Arcisati, 400 m, coll. Corti, 82615, Varenna (Lago di Como), coll. L. Scannagotta 3. III. 47, JE; Prov. Pavia, Torre d'Isla, coll. F. A. Artaria 1932, JE.

Switzerland

Vernayaz, coll. Bertram, 1873, JE.

Austria

Leoben, Gössgraben, 1870, coll. BREIDLER, 118756, *Niederösterreich:* Schlucht bei . . . Göttweig, 250 m, kalkhaltige Boden, coll. BAUMGARTNER 20. X. 1892, JE.

Germany

Allgäu, Hinterstein, auf einem Stein . . ., 840 m, 1889, ex Hb. LIMPRICHT, 42297, 42298, 42281; Memmingen: Schlossberg in Grönenbach, 705 m, 1880, coll. HOLLER, ex Hb. LIMPRICHT, 42283; Ebingen a. D., 1916, coll. EGGLER, 11875; *Braunschweig*, Münzberg, coll. BERTRAM, 118743; *Baden-Baden:* Hohentwiel bei Singen, 1898, coll. HERZOG, ex. Hb. LIMPRICHT as fo. *rupicola*, 42292; *Oberbaden*, beim Salem, coll. LACK (?), ex Hb. LIMPRICHT, 42290; Eifel, Ripsdorf, in Nischen schattiger Kalkfelsen am Lampertsbach, 460 m, coll. ANDRES, P. WIRTGEN: Herbar plant. crit. select. hybrid. Florae Rhenanae No. 226, 42286; Schlossgarten an Rheinsberg, coll. VON LOEWENSTEIN, Aug. 1855, JE; Eibenschlucht bei Eddigehausen, coll. QUELLE, 7. 2. 1903, JE; An Kalkfelsen des Isteinerklotzes, ca 300 m, coll. TH. HERZOG, Dez. 1898. JE; *Oberbayern:* Kalkfelsblöcken am Ufer des Königsees, ca 610 m, coll. TH. HERZOG, 30. Aug. 1919, JE; and other localities.

France

Alsace, s.l.sp. com. Ph. Schimper, ex Hb. LIMPRICHT, 42272; Fontaine près Grenoble (Isère), rochers calcaires dans les bois, coll. PELLET, Societé Dauphinoise No. 2695, 7850.

Belgium

Namur, près de Han sur Lesse, rochers calcaires ombragés, 1886, coll. VANDENBROECK et DENS, 7848.

REFERENCES

BÄUMLER, J.: (1884): Die Moosflora von Pressburg in Ungarn. Österreichische botanische Zeitschrift **34,** 96—99.

BOROS, Á. (1924): Beiträge zur Moosflora Ungarns. Magyar Botanikai Lapok **23,** 77—80.

BOROS, Á. (1932): A Nyírség flórája és növényföldrajza. Debreceni Honism. Biz. kiadv. **7,** 1—208.

BOROS, Á. (1942): Adatok a Székelyföld flórájának ismeretéhez. Scripta Bot. Mus. Transs. **1,** 144—147.

BOROS, Á. (1943): A Lápos és Kapnik szurdokának flórája. Scripta Bot. Mus. Transs. **2,** 141—149.

BOROS, Á.—VAJDA, L. (1952): Ergänzungen zur Moosflora der Ungebung von Budapest und des Buda-Pilis-Gebirges. Ann. Mus. Nat. Hung. **3,** 47—77

BOROS, Á.—VAJDA, L. (1955): Für die Flora Ungarns neue und interessante Moose, Ann. Mus. Nat. Hung. **4,** 155—165.

BOROS, Á.—VAJDA, L. (1969): Bryoflora Carpathorum septentrionali-orientaliorum. Revue Bryol. et Lichenol. **36,** 397—450.

HÄMET-AHTI, L.—AHTI, T.—KOPONEN, T. (1974): A scheme of vegetation zones for Japan and adjacent regions. — Ann. Bot. Fennici **11,** 59—88.

HAZSLINSZKY, F. (1855): Beiträge zur Kenntnis der Karpathen-Flora. VII. Laubmoose. Verhandlungen der zool.-bot. Ges. in Wien **5,** 765—776.

HAZSLINSZKY, F. (1857): Die Laubmoose der Eperjeser Flora, Verhandlungen des Vereins für Naturkunde zu Pressburg. **2,** 1—10.

HAZSLINSZKY, F. (1885): A magyar birodalom moh-flórája. Budapest, 280 pp.

IWATSUKI, Z.—KOPONEN, T. (1972): On the taxonomy and distribution of Rhodobryum roseum and its related species (Bryophyta). Acta Bot. Fennica **96,** 3—22.

KUC, M. (1964): Briogeografia Wyżyn Południowych Polski. Monogr. Bot. **17,** pp. 212.

LATZEL, A. (1934): Beitrag zur Kenntnis der Moose der Komitats Baranya. Magyar Botanikai Lapok **33,** 160—191.

LATZEL, A. (1941): Beitrag zur Kenntnis der Moose des Ostalpenrandgebiets, Beihefte zum Bot. Centralblatt **61,** 211—260.

ORBÁN, S.—DEBRECZY, Zs. (1973): Moos-arealgeographische Studien aus dem Gebiet der Karpaten und Karpatenbecken. Studia Bot. Hung. **8,** 65—98.

PAVLETIĆ, Z. (1955): Prodromus Flore Briofita Jugoslavije. Jugoslavenska Akad. Znanosti i Umjet., Zagreb 1955, 575 pp.
PÉTERFI, M. (1896): Déva lombosmohái. Kolozsvári Orv. Term. Tud. Társ. Értesítője **21,** 129—144.
PETROV, S. (1975): Bryophyta Bulgarica clavis diagnostica. Izd. Akad. Nauk. Bulg. Sofia, 536 pp.
ŠMARDA, J.—VANEK, R. (1955): Treti dopelnek k mechum Slovenska. Prace II. sekcie Slovensk. Akad. Vied. **1,** 9. Bratislava.
SOÓ, R. (1942): Pótlékok a nyírségi és tiszántúli flórakutatásunk eredményeihez. III. Bot. Közlemények **39,** 45—56.
SZEPESFALVI, J. (1942): Die Moosflora der Umgebung von Budapest und des Pilisgebirges. Ann. Mus. Nat. Hung. **35,** 1—72.
VAJDA, L. (1969): A Sátorhegység mohaflórája. Fragmenta Bot. Hung. **7,** 93—120.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (3—4), pp. 449—461 (1976)

OBSERVATION OF ONE POLLEN GRAIN BY SEM, TEM, AND LIGHT MICROSCOPY

By

J. R. ROWLEY and M. JÁRAI-KOMLÓDI

INSTITUTE OF BOTANY, UNIVERSITY OF STOCKHOLM, STOCKHOLM, SWEDEN
AND DEPARTMENT OF PLANT TAXONOMY AND ECOLOGY, EÖTVÖS LORÁND UNIVERSITY, BUDAPEST, HUNGARY

(Received August 10, 1976)

Plastic embedded cells and tissues prepared for transmission electron microscopy (TEM) are commonly and favorably used for light microscopy (LM) but seldom "directly" for scanning electron microscopy (SEM), although the advantage of having comparable specimens for light and transmission electron microscopy is evident. Fractured chips or sections of plastic embedded cells, which may be the same as those used for LM and serial with thin sections for TEM, are favorable for SEM following removal of the embedding plastic. The method used was developed by MAYOR, HAMPTON and ROSARIO (J. Cell. Biol. 9 : 909—910, 1961) to expose embedded tissues to aqueous metachromatic dyes by removal of epoxy-resin formulations incorporating dodecenyl succinic anhydride as a hardener. Our emphasis was upon rehydration of the protoplast in pollen from herbarium specimens, to expand germinal apertures, and to optimally retain soluble components such as tryphine and the polysaccharide and protein exine surface coating. A demonstration of the exine surface coating in SEM micrographs was a prime objective since the specific composition of cell surface coatings in other cell systems forecast, its unprecedented potential for taxonomy and studies of genetical and ecological control over pollen grain form, and SEM (especially X-ray microanalysis) is likely to be important for characterization of surface coatings following appropriate labeling or enzymatic digestion. While the methods we use for LM, TEM, and SEM observation of portions of the same pollen grain can be used following any surface cleaning or extraction procedures, preservation of the exine surface coating offers a special advantage in facilitating SEM observations of pollen grains and spores without recourse to evaporated or sputtered metals. This occurs because of the far greater binding capacity of coat components for metals than the exine itself.

Introduction

Pollen of *Linaceae* can be traced from the upper Senonian (GERMERAAD et. al., 1968; MULLER, 1970) and has a long history of cultivation. One of us (M. J.-K.) has selected the genus *Linum* for intensive study both with regard to pollen from sediments and the 200 or so extant species. Species that presently grow in Hungary will be examined from various soil and other ecologically divergent localities to determine whether ecological conditions alter pollen form in ways which can be detected by light microscopy (LM), scanning electron microscopy (SEM), and transmission electron microscopy (TEM). In order that observations with these instruments be comparable it is judged necessary not only for methods of preparation to be identical but, also, in so far as possible, that the same pollen grains be used for LM, SEM, and TEM observations of critical features.

There are several methods which allow, with various levels of facility, for multiple modes of observation on portions of the same cells of a tissue sample (e.g., WICKHAM and WORTHERN, 1973; BAUMAN and MENDELL 1974; HUMPHREYS, WODZIKI, and PAULIN 1973). They involve cutting thin sections from sections previously used for LM by reattaching the thick section to a plastic block, fracturing plastic embedded specimens for SEM before or after cutting sections of the material for LM and TEM, or embedding SEM examined specimens in plastic for TEM use. HUMPHREYS et al. (1973) have used their fractographic method to study xylem differentiation in *Pinus* (WODZICKI and HUMPHREYS, 1973; WODZICKI and BROWN, 1973), notably with regard to the interior organization of protoplasts. With pollen grains embedded in plastic we find that while fracturing frequently bisects the grains, the surface of the exine including apertures may also be exposed. While it is difficult to obtain sections for LM and TEM from the same pollen grains that are also fractured for SEM, preparation of SEM specimens by the fractographic method is dependable, exceptionally easy, and entirely free of solvents.

The method we have used involves removal of the embedding plastic from sections previously examined by LM or from thick sections or a fractured chip serial with previously cut sections for LM and TEM.

Methods

Materials and methods unrelated to removal of the embedding plastic are considered in the results and discussion section or included in the illustration descriptions.

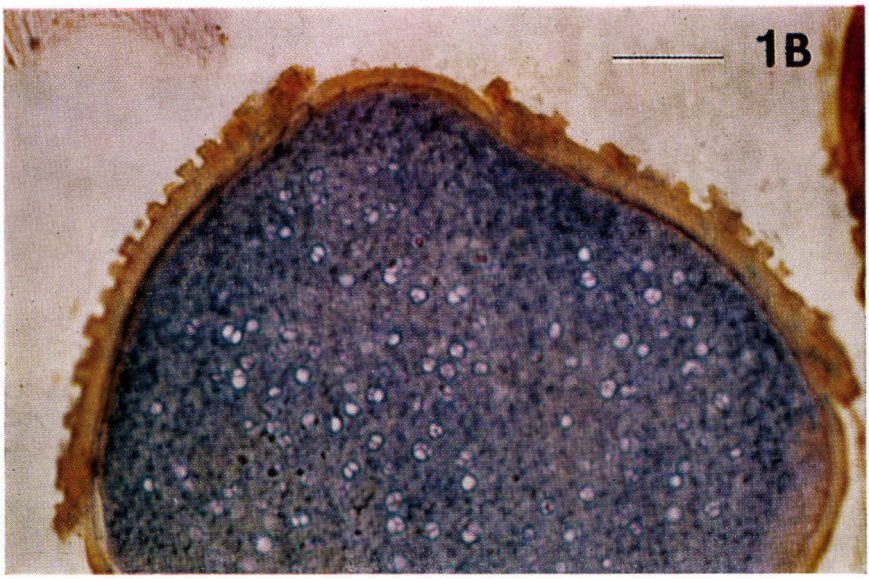
Epoxy resin formulations using dodecenyl succinic anhydride as a hardener can be dissolved in a mixture of sodium, benzene and methyl alcohol (MAYOR, HAMPTON, and ROSARIO 1961). The preparation of sodium methoxide is described by MAJOR et al. (1961) and PEASE (1962: p. 262). Metallic sodium (2.5 gm) is cut into 2—5 mm cubes and dropped piece by piece into methyl alcohol (25 ml) in a flask in a chemical hood. The sodium should be added quickly because a temperature above 50°C is necessary for the reaction. The original level of the methyl alcohol should be marked so that the alcohol that evaporates may be replaced. When the sodium is dissolved and evaporated alcohol replaced, benzene (25 ml) is added. If there is a phase boundary, then add methyl alcohol until the mixture is clear. This stock solvent mixture can be stored indefinitely.

Epoxy resins are dissolved rapidly and even large pollen grains will be free of the plastic within 30 sec to several minutes. The reaction is stopped by flooding the specimen with a 1 : 1 mixture of methyl alcohol and benzene. MAYOR et al. washed with two changes of acetone followed by distilled water where the objective was to improve the results with aqueous stain such as toluidine blue. In the preparation of specimens for SEM rinsing with water may be disadvantageous with regard to surface tension and contamination, and we washed either with acetone or methyl alcohol.

Sections or fractured chips of plastic containing the pollen are attached to SEM specimen pins with conductive cement. Since only a drop of sodium methoxide is required, it is convenient to follow the reaction with a stereoscopic microscope and stop its progress with fluid held in a PASTEUR pipette. If the specimen consists of thin sections or the pollen grains are small, it is desirable to dilute the stock mixture with equal parts of methyl alcohol and benzene. For reactions of longer duration than a minute, the addition of fresh sodium methoxide solution may help to prevent formation of a precipitate over the specimen. There is a great deal of bubbling during the dissolution process and as the reaction is stopped, although, after washing, the exposed pollen grains are clean in appearance and pollen grain size is unaltered.

Results and discussion

Observers desiring pollenmorphological information from a combination of LM, TEM, and SEM are commonly dependent upon pollen grains prepared by different techniques. As a result it is difficult or impossible to be assured that the preparations are comparable, especially with respect to shrink-



Figs 1A and *1B*. LM Photomicrographs of ca. 1 μm epon-araldite sections of *L. tenuifolium* pollen grain stained with 0.05% toluidine blue in benzoate buffer (pH 4.5). The germinal apertures at the top and left in the figures are serial with micrographs in figures 2 and 3. Scale line: ca. 10 μm

age and expansion. The pollen grain exine is both plastic and elastic (BANERJEE, ROWLEY, and ALLESIO 1965; and MATSON 1976) so that specimen preparation may effect size and shape of exine perforations, the width of muri, relationship of apertural parts, and other fine details of exine structure and sculpture as well as overall pollen size, which in itself may or may not be considered of great significance. As a result, subtle variations in morphology may have to be regarded with reservation or ignored. Whereas the minor alterations in pollen morphology could have considerable importance if they are characteristic of a taxon (Fig. 6). Positive evidence for exine variation within a genotype has wide application in areas such as evolution of the exine, concerning, e.g., whether the phenotype may be affected by its own haploid genetic content ("haploid effect", cf. BEATTY 1975), or the evaluation of possible environmental effects (HEBDA and LOTT 1973).

It is common practice to cut 1 μm or thicker sections for LM before or after cutting thin sections for TEM. Relatively thin sections used for phase or interference contrast (Nomarski) microscopy can reduce the need for TEM observations and sections as thick as the diameter of the pollen grains, which may be satisfactorily cut with a razor blade by hand, are valuable in conjunction with whole pollen preparations since they will include exposed sections of the exine and may be exactly comparable with TEM observations. Sections of intermediate thickness that will include extensive areas of exine surface can supplant many routine SEM observations. TRAVERSE (1974: p. 228) has considered the utility of interference contrast microscopy in the latter regard with respect to relative cost and information.

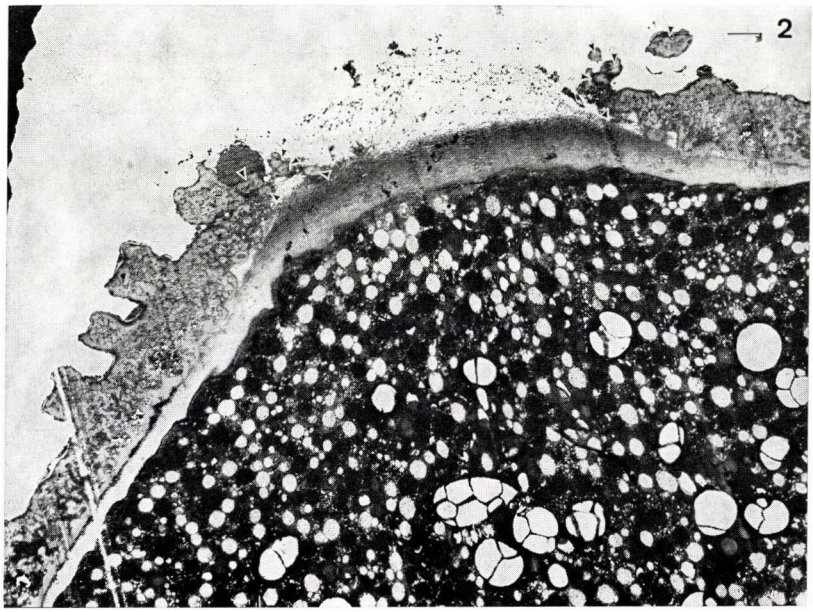


Fig. 2. TEM micrograph 1—5 m poleward from the uppermost aperture in Fig. 1. The other end of this aperture is shown in Fig. 4. Several small exinous processes (arrow heads) are seen near the aperture margin, those at the right are reflexed over the aperture margin. Section stained with 1% phosphotunstic acid in 10% chromic acid (PTA chrom). Scale line: ca. 1 μm

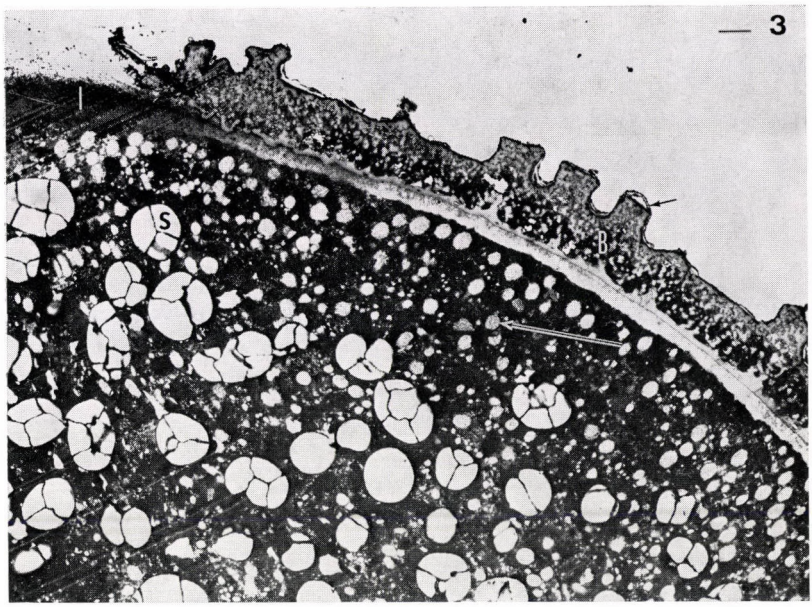


Fig. 3. TEM micrograph serial with the aperture at the left sides of Figs 1A and 1B. The thickened intine (I) of the apertural region is stained by the osmium tetoxide-ruthenium red-thiocarbohydrazide (TCH)-osmium post-rehydration treatment and the conductivity conferred by these metals is considered responsible for the dark appearance of apertures in SEM immages (cf. Figs 4 and 5). Section staining with PTA chrom further darkens the apertural intine and stains the exine surface coating (short arrow), fibrillar network in the bacular arcade (B), and acidic polysaccharide in cytoplasmic vesicles (long arrow). Starch grains are darkened by periodic acid oxidation followed by TCH and silver proteinate but not by PTA chrom staining. Scale line: ca. 1 μm

The simplest and in several respects the best way to mount and examine plastic embedded sections for LM is to heat the microscope slide sufficiently (60—80°C) to slightly melt and thus seal the sections to the glass. Except for very thick sections the sections are transferred from the knife reservoir to a drop of water on the slide by means of a water film held by a wire loop (ca. 5 mm in diameter). As the sections are examined with oil immersion objectives (we used 50× and 100× objectives), placing the oil directly on the plastic sections obviated the difficulty caused by varying section thickness (from less than 1 μm to 30—40 μm) when a cover glass is used. Immersion oil may be removed from the sections by drawing lens paper over the slide following application of benzene. Thick sections can be detached from the slide with a razor blade and transferred to a coating of adhesive on an SEM specimen pin. The sections ought to be released from the glass surface under a small plastic pouch cut from the corner of a plastic bag, as HUMPHREYS et al. (1973) recommend to prevent loss of chips fractured from embedded material. A dissection needle coated with a viscous liquid facilitates transfer of sections or chips. Dodecenyl succinic anhydride is favourable as it will not interfere with dissolution of the epoxy embedding resin.

Examination of plastic sections with LM and subsequent removal and orientation of sections for SEM may be aided by staining. Any of the basic dyes used by palynologists to stain the pollen exine or many of the botanical staining procedures described by FEDER and O'BRIEN (1968) may be applied to plastic embedded sections which have been affixed to slides by heat. MAYOR et al. (1961) used sodium methoxide to remove epoxy resin from sections in order to take advantage of metachromasia, using basic dyes such as toluidine blue. They reported that thick sections with resin removed stained brilliantly and revealed excellent cellular detail with the light microscope.

Our *Linum* pollen was obtained from herbarium specimens. Anthers from mature flowers were wetted in a mixture of 1% tannic acid and 1% glutaraldehyde (TAG) in 0.1 M

Fig. 4. SEM micrograph of pollen grain from which sections were made for the photomicrographs in Fig. 1 and TEM micrographs in Figs 2 and 3. The aperture "A" is part of the uppermost aperture in Figs 1A and 1B. The sodium methoxide solvent generally removed the epoxy resin embeddant from the exine surface and profiles of exine processes are similar in SEM (between arrowheads) and TEM micrographs. The material marked with a "T" is anther debris from the herbarium material used as a source of pollen. The bridges between exine processes (short arrows) are considered to consist of exine surface material or tryphine (Figs. 7 and 8). Dark regions (long arrows) on the exine surface, where surface charging is low, are considered to be due to thickened exine surface coating (cf. right side of Fig. 8). Scale line: ca. 10 μm

phosphate buffer (pH 7.3, room temp.) as described by FUTAESAKU, MIZUHIRA, and NAKAMURA (1972) and RODEWALD and KARNOVSKY (1974). The anthers were then cut into several pieces, placed in a vial of TAG solution, shaken vigorously, and the pollen separated from most of the anther debris, using a screen. The residue containing the pollen was centrifuged and the resulting pellet of pollen encapsulated in a cold agar tube previously formed by immersing the tip of a PASTEUR pipette into hot 2% agar. The agar vial was sealed with a warm instrument and the agar encapsulated pollen was returned to a TAG solution for 24hrs. The agar capsule was lifted out of TAG, drained and placed in 0.1 M glutaraldehyde in 0.1 M sodium cacodylate-HCl buffer (pH 7, 315 milliosmoles, room temp.). The rationale for the last step was (first) to remove excess tannic acid without resorting to a water rinse and (second) to reduce the osmolality to 310—320 milliosmoles, empirically determined to approximate the osmolality of the pollen protoplast. The pollen was left in this mixture for 2—12hrs or until expansion of the pollen was observed to be satisfactory. Should the pollen become overexpanded or remain partly collapsed, the osmolality could be increased or decreased by altering the concentration of the buffer or glutaraldehyde; the histograms in MASER, POWELL, and PHILPOTT (1967) may be used if an osmometer is unavailable. The agar capsule containing the pollen was then dropped into a solution of 0.1% osmium tetroxide in glass-distilled water (pH 6) without washing out the glutaraldehyde.

Staining with osmium was the first step in binding heavy metals to the exine surface coating and osmiophilic components within the intine and cytoplasm to provide a conductive material to prevent an uneven buildup of electrons when the pollen was later exposed to a scanning electron beam. HANKER, DEB, WASSERKRUG, and SELIGMAN, WASSERKRUG and HANDER (1966) showed that cations added to tissue by stain procedures or cations native to

tissues can be amplified through the use of ligands. They demonstrated that one end of multivalent ligands, such as thiocarbohydrazide (TCH), was bound to a metal in the tissue while the other end(s) remained free to bind to additional metal ions. Extensive use is made of the principle in THIERY's (1967) modification of the PAS reaction where TCH is employed to bind to aldehydes freed by periodic acid oxidation and silver proteinate, then bound to TCH to provide the contrast necessary for TEM observation. Ligand-mediated osmium binding has been employed by KELLEY, DEKKER, and BLUEMINK (1973) to give a metal coating to soft biological tissues and these gave adequate conductivity to entirely circumvent evaporated metal–carbon coating of SEM specimens at acceleration voltages up to 25 kV.

As we employed the ligand method, the pollen in agar was lifted out of the glutaraldehyde solution and drained before being placed in a solution of 0.1% OSO_4 in glass-distilled water (pH 6, 20°C) or 0.1% OsO_4 plus 0.1% ruthenium red for ca. 2hrs. The pollen grains were then rinsed in 3 changes of 10% acetic acid for a total of ca. 15 min, transferred to 0.1% TCH dissolved in 10% acetic acid, and washed for 15 min in 3 changes of 10% acetic acid to remove unbound TCH. After washing in 3 changes of water, the agar-encapsulated pellet of pollen was placed in 2 ml of 0.1% OsO_4 for 2hrs then 2 ml of 70% acetone was added to begin the dehydration. Thereafter, at 10 min intervals, the pollen was transferred through an acetone series which included 5 changes of 100% acetone. Embedding was in MOLLENHAUER's (1964) mixture No. 1 consisting of epon and araldite with polymerization in an oven at 80°C.

The photomicrograph in Figure 1 and electron micrographs in Figures 2—3 are serial sections from the *Linum tenuifolium* pollen grain shown in the SEM micrograph in Figure 4. The sections and SEM micrographs in Figures

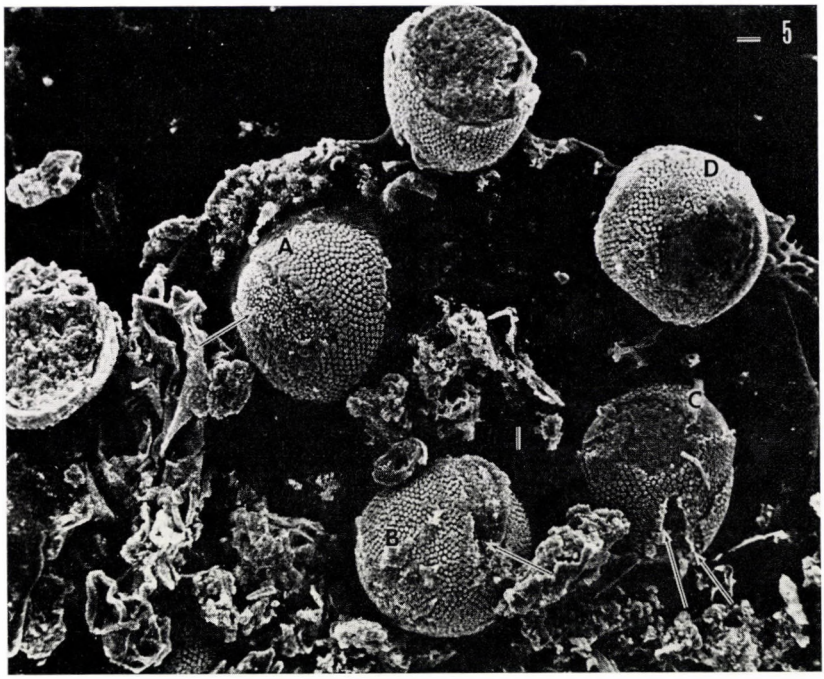


Fig. 5. SEM micrograph of six pollen grains and anther cell remains protruding from a partially dissolved epon-araldite section. Two of the grains (C and D) became free of the embedding plastic and rotated. The aperture membrane on grain "A" is flecked with exinous processes (arrow). Whereas there are only a few small processes (arrow) on the aperture of grain "B" and essentially none on the apertures of grain "C". There is gathered-up material (arrows) at the apperture margin of grain "C" (also apparent on grains "A" and "B") which is considered to be the reflexed apertural membrane. Magnification scale line: ca. 10 μm

Fig. 6. Some exine processes of *L. tenuifolium* pollen are straight-sided, while others are concave. The proportion of these two types in the grain prepared for LM, TEM, and SEM (Figs 1—4 and 5) is three — four concave to one with straight sides. The area and shape of the distal surface of exine processes in that grain is markedly variable. Processes having four protruding knobs (see Fig. 4) are squarish while those with three or two knobs are triangular and elliptic respectively and have progressively reduced surface areas. Variation in size of processes is also apparent in grain "B" of Fig. 5 while processes appear fairly uniform in size in grains "A" and "C" of Fig. 5. These are examples of distinctions, like the flecking on the aperture of gains "A" of Fig. 5, that are amenable to critical assessment through examination of selected individual pollen grains by LM, TEM, and SEM.

5—10 are from the same plastic block as the grain in Figures 1—4. In Figures 4—5 and 9—10 the epon-araldite was partially dissolved in sodium methoxide (1 min for the section used in Fig. 5 and 2 min for Figs 4 and 9 and the fractured chip in Fig. 10 at stock solution concentration).

The verrucoid exinous processes which appear to be monomorphic with the light microscope are found to be variable in two respects in at least some grains from the single plant used for our study. These variables are described and illustrated in Figs 4 and 6. The hexagonal arrangement of exine processes

causes aperture margins to be slightly irregular (Fig. 4) but exine processes are not evident on the aperture membrane in the sectioned grains. SEM observations, however, show apertures with and without small processes on the aperture membrane (Fig. 5).

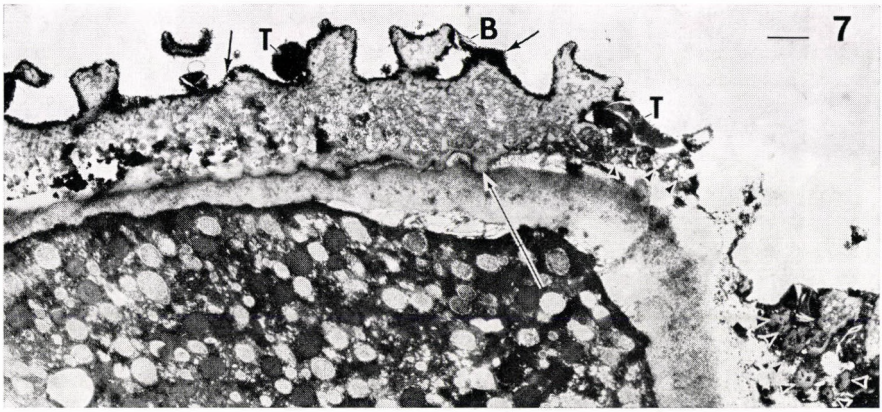


Fig. 7. Uncharacterized substances on the surface of pollen grains, commonly called tryphine and believed to originate from tapetal cells, occur in our material both external to the exine surface coating (short arrows) and between that coating and the exine (cf. Fig. 8). Tryphine (T) located external to the exine surface coating may bridge (B, see also Fig. 4) exine processes. The undulations (long arrow) which are typical of the proximal surface of the exine form a reticulum (cf. Fig. 10). The small exine processes (arrow heads) at the aperture margin are considered to have been located over the aperture membrane (cf. Fig. 5) prior to dehydration or subsequent processing. Stain: PTA chrom. Scale line: ca. 1 μm

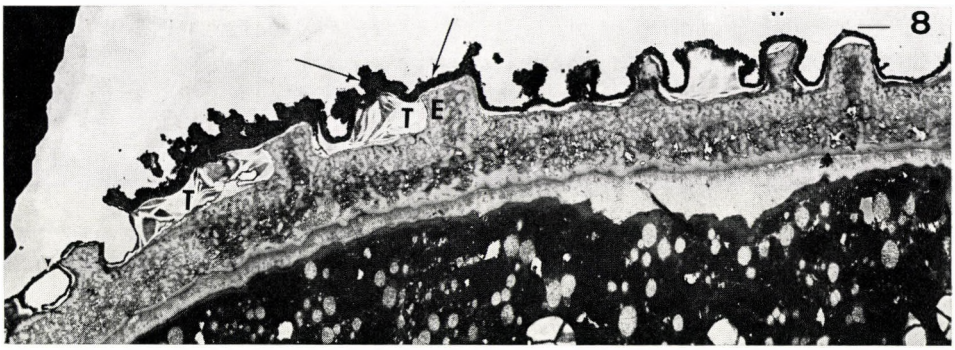


Fig. 8. The exine surface coating in the grains examined is thickened in regions where tryphine (T) occurs between the exine (E) and exine surface coating (arrows). In SEM micrographs, regions where the exine surface coating is extensively thickened are recognized by a globular texture (cf. Fig. 9) and a localized reduction in surface charging (cf. Figs 4 and 9) due, to metal bound to the surface coating during post-rehydration staining. At the left margin an arrow head marks a loop of exine coating material from which tryphine has been extracted. The distal part of that loop bridges two exine processes (cf. Fig. 4). Stain: PTA chrom. Scale line: ca. 1 μm

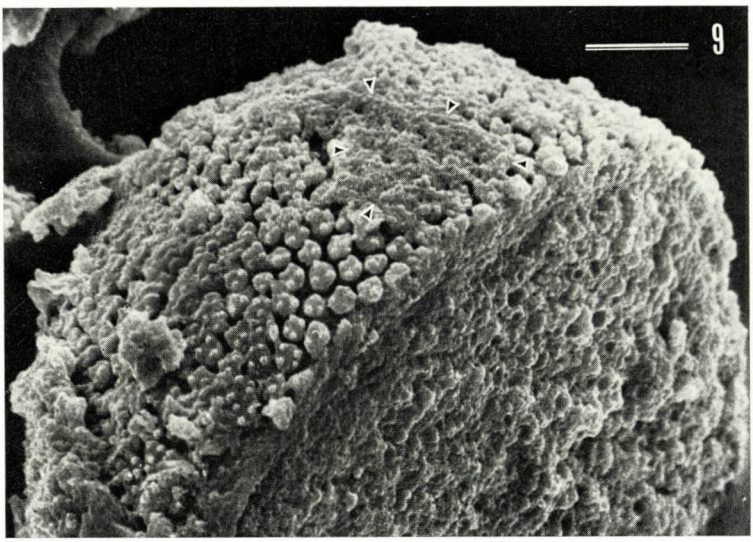


Fig. 9. The surface area delimited by arrow heads is considered to be exine surface coating probably underlain by tryphine as in Fig. 8. The tannic acid and gluteraldehyde fixative used for rehydration of the pollen grains is favorable for preservation of the polysaccharide and protein containing exine surface coating and all exine surfaces in our illustrations (except the fractured surface in Fig. 10) include the exine surface coating. In general, this coating is thin and attached to the exine and does not greatly interfere with morphological obsevation. The capacity of exine surface coat components for binding metals can be used to advantage in the control of specimen surface charging during SEM observation. Scale line: ca. 10 μm

The SEM images of apertures which are devoid of exinous flecking on the apertural floor show that there are folds of material at one or both sides of apertures (Fig. 5). They look as though the exinous covering of the aperture floor had parted and then had been gathered up adjacent to the margin. Our attention was thus guided to material at the aperture margin in TEM micrographs in which exinous processes were missing from apertures. In most sections of apertures we found that there were several to many small exinous processes either adjacent to the aperture margin (Figs. 2 and 7) or reflexed over the margin (Fig. 2).

While we had considered small processes covering the apertural floor to be characteristic of some species, it became apparent that the occurence of these processes on the floor of apertures was likely to be a general phenomenon in the genus *Linum*. Persistence of the apertural membrane may perhaps vary with species, although maturation of the sample and subsequent handling must be considered in any description of apertures in pollen of *Linum*. In ERDTMAN's (1952) descriptions of pollen grains of *Linum* only the colpi of one species (*L. perenne*) are indicated as covered by verrucose membranes and these showed the same pattern as in the meso- and apocolpia.

Attention is given to the exine surface coating because of the potential

of these coatings in pollen morphology–taxonomy and other applications demanding specific identifications and characterizations. Work with exine surface coatings has been limited to positive staining for protein and acidic polysaccharides and binding of cationic dyes (e.g., ROWLEY 1971, PETTITT and JERMY 1974) and the identification of sialic acid as a component of the exine coating of spores of the fern *Botrychium lunaria* (PETTITT and JERMY 1974). From this evidence it can be concluded that exine surface coatings are composed of mucopolysaccharides or glycoprotein. The data now available, however, for plant cell plasma membrane-glycocalyces are still few and insufficient and the conclusions that can be drawn are therefore bound to facts which were established for the cell coats of animal cells. It is likely that the mucopolysaccharide or glycoprotein composition of exine surface coatings is highly specific.

Retention of the exine surface coating is advantageous for SEM observation, even though no attention is directed toward their presumed specific

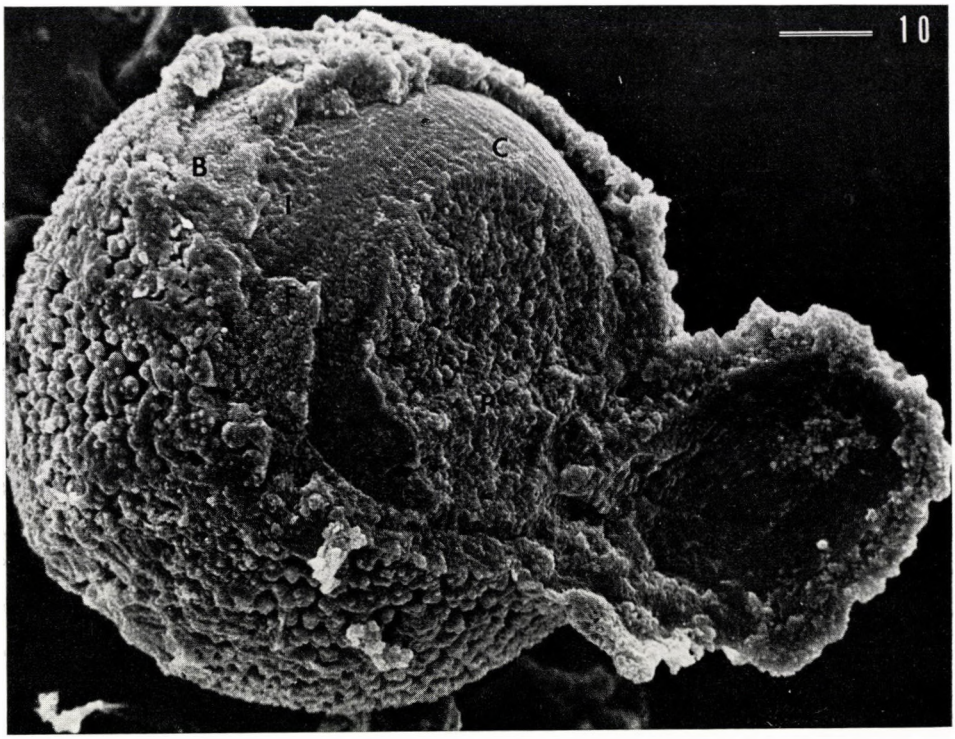


Fig. 10. A fracture has exposed the middle portion of the complex bacular (B) zone of the exine, the distal surface of the footlayer (F) revealing the origins of numerous bacules (compare with section in Fig. 8), the distal surface of the intine (I), the surface of the cytoplasm (C), and part of the cytoplasm (P). The interlaced ridges on the distal surface of the intine (I) reflect the pattern of the exine–intine contact (cf. Figs 7 and 8). Scale line: ca. 10 μm.

composition. The binding capacity of these polysaccharide–protein coatings far exceeds that of the exine itself, as can be appreciated in Figs 2—3 and 6—8. With appropriate staining the exine surface coating can be used to provide a conducting surface that will eliminate the need for the addition of metals or allow for favorable results using evaporated carbon, which is relatively transparent to electrons.

The acidic polysaccharide and protein-containing exine surface coating in germinal apertures of *Oxalis rosa* pollen is [ROWLEY and SKVARLA (1976)] in intimate contact with the endexine, and ROWLEY and DAHL (in press) determined that there is continuity between the exine surface coating and endexine-interbedded intine in pollen of *Artemisia vulgaris*. Thus, it is not unreasonable to suggest that the greatly thickened exine surface coating we find to occur over the exine in regions rich in tryphine, as in Fig. 8, became thickened in response to the presence of tryphine substances, or that the exine surface coating of *L. tenuifolium* pollen be provisionally considered as an absorptive component of the protoplast surface.

The acceptability of pollen grains obtained from herbarium specimens for cytological or histochemical studies is worthy of assessment during the present period of increasing cost for travel, diminishing funds to maintain botanical gardens and other live collections, and an estimated 20,000 species of flowering plants at risk of extinction (MYERS 1976). Pollen grains are in general programmed to be dehydrated and maintenance of fresh grains under high vacuum or in dry solvents such as acetone prolongs pollen grain viability. With the same attention to the composition and osmolality of rehydration that would be given living tissues prepared for histochemical detection of carbohydrates, protein, or lipids, we find that the results of staining procedures (e.g., PTA in acetone for protein, PTA in chromic acid for acidic polyanions and osmium tetroxide for unsaturated lipids) are comparable with those performed on pollen grains fixed from the living condition.

ACKNOWLEDGEMENTS

The SEM micrographs were made through the generosity of the Scandinavian JEOL Company. We wish to thank Mr. K. HORIE for making the arrangements and Mr. AOYAGI for patiently examining our experimental material. The work was supported by grants from the Swedish Natural Science Research Council. A visiting scientist exchange fellowship (for M. J.-K.) from the Swedish Academy of Science and the Hungarian Academy of Sciences is gratefully acknowledged. We are grateful to ELISABETH GRAFSTRÖM and ERIC ROWLEY for technical assistance.

REFERENCES

BANERJEE, U. C., ROWLEY, J. R. and ALESSIO, M. L. (1965): Exine plasticity during pollen grain maturation. J. Palynol. **1,** 70—89.

BAUMAN, D. and MENDELL, J. R. (1974): Method of re-embedding tissue for electron microscopy. Stain Technol. **49,** 118—119.

BEATTY, R. A. (1975): Genetics of animal spermotozoa. In: Gamete Competition in Plants and Animals (D. L. MULCAHY, ed.) pp. 61—68. North-Holland Pub. Co., Amsterdam.
ERDTMAN, G. (1952): Pollen Morphology and Plant Taxonomy. Angiosperms. Almqvist and Wiksell, Stockholm.
FEDER, N. and O'BRIEN, T. P. (1968): Plant microtechnique: Some principles and new methods. Amer. J. Bot. **55,** 123—142.
FUTAESAKU, Y., MIZUHIRA, V. and NAKAMURA, H. (1972): A new fixation method using tannic acid for electron microscopy and some observations of biological specimens. Proc. Int. Congr. Histochem. Cytochem. **4,** 155.
GERMERAAD, J. H., HOPPING, C. A. and MULLER, J. (1968): Palynology of tertiary sediments from tropical areas. Rev. Palaebotan. Palynol. **6,** 189—348.
HANKER, J. S., DEB, D., WASSERKRUG, H. L. and SELIGMAN, A. M. (1966): Staining tissue for light and electron microscopy by bridging metals with multidentate ligands. Science, **152,** 1631—1634.
HEBDA, R. J. and LOTT, J. N. A. (1973): Effects of different temperatures and humidities during growth on pollen morphology: an SEM study. Pollen Spores, **15,** 563—571.
HUMPHREYS, W. J., WODZICKI, T. J. and PAULIN, J. J. (1973): Fractographic studies of plastic-embedded cells by scanning electron microscopy. J. Cell. Biol. **56,** 876—880.
KELLEY, R. O., DEKKER, R. A. F. and BLUEMINK, J. G. (1973): Ligand-mediated osmium binding: its application in coating biological specimens for scanning electron microscopy J. Ultrastruct. Res. **45,** 254—258.
MASER, M. D., POWELL, T. E., III and PHILPOTT, C. W. (1967): Relationships among pH, osmolality, and concentration of fixative solutions. Stain Technol. **42,** 175—182.
MATSON, O. (1976): The development of dimorphic pollen in Tripogandra (Commelinaceae). In: The Evolutionary Significance of the Exine (I. K. FERGUSON and J. MULLER, eds.) Linnean Society Symposia Series No. 1.
MAYOR, H. D., HAMPTON, J. C. and ROSARIO, B. (1961): A simple method for removing the resin from epoxy-embedded tissue. J. Cell. Biol. **9,** 909—910.
MOLLENHAUER, H. H. (1964): Plastic embedding mixtures for use in electron microscopy. Stain Technol. **39,** 111—115.
MULLER, J. (1970): Palynological evidence on early differentiation of angiosperms. Biol. Rev. **45,** 417—450.
MYERS, N. (1976): An expanded approach to the problem of disappearing species. Science **193,** 198—202.
PEASE, D. C. (1964): Histological Techniques for Electron Microscopy. Academic Press, New York.
PETTITT, J. M. and JERMY, A. C. (1974): The surface coats on spores. Biol. J. Linn. Soc. **6,** 245—257.
RODEWALD, R. and KARNOVKSY, M. J. (1974): Porous substructure of the glomerular slit diaphragm in the rat and mouse. J. Cell. Biol. **60,** 423—433.
ROWLEY, J. R. (1971): Implications of the nature of sporopollenin based upon pollen development. In J. BROOKS, M. D. MUIR, P. VAN GIJZEL and G. SHAW (Eds.), Sporopollenin, pp. 175—218. Academic Press, London.
ROWLEY, J. R. (in press): Pollen development in Artemisia vulgaris with special reference to glycocalyx material. Pollen et Spores.
ROWLEY, J. R. and SKVARLA, J. J. (1976): Surface coating of germinal apertures of pollen and evolution of apertures. 34th Ann. Proc. Electron Microscopy Soc. Amer., G. W. BAILEY (ed.).
SELIGMAN, A. M., WASSERKRUG, H. L. and HANKER, J. S. (1966): A new staining method (OTO) for enhancing contrast of lipid-containing membranes and droplets in osmium tetroxide-fixed tissue with osmiophilic thiocarbohydrazide (TCH). J. Cell. Biol. **30,** 424—436.
THIÉRY, J. P. (1967): Mise en évidence des polysaccharides sur coupes fines in microscope électronique. J. Microscopie, **6,** 987—1018.
TRAVERSE, A. (1974): Paleopalynology 1947—1972. Ann. Missouri Bot. Gard. **61,** 203—236.
WICKHAM, M. G. and WORTHEN, D. M. (1973): Correlation of scanning and transmission electron microscopy on the same tissue sample. Stain Technol. **48,** 63—68.
WODZICKI, T. J. and BROWN, C. L. (1973): Organization and breakdown of the protoplast during maturation of pine tracheids. Amer. J. Bot. **60,** 631—640.
WODZICKI, T. J. and HUMPHREYS, W. J. (1973): Fracturing plastic embedded plant material for scanning electron microscopy. Micron **4,** 1—9.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (3—4), pp. 463—474 (1976)

THE CURRENT SPACE DEMAND AND ITS VARIABILITY DURING DEVELOPMENT OF PIMPINELLA ANISUM L.

By

J. SZUJKÓ-LACZA

BOTANICAL DEPARTMENT, HUNGARIAN NATURAL HISTORY MUSEUM, BUDAPEST

(Received June 20 1976)

Continuing the quantitative morphological analysis of anise, the authoress investigated and found of the present work points of measurement whose data allowed the calculation of space occupied or "filled" by the various individuals at a given stage of growth and in its turn its phenophases as well. She has termed this space as current space demand (CSD), for its very linkage to the stages of ontogenesis. In the population examined there has occured a variability with respect to the degree of development and space demand. The maximum CSD could best be measured in the more developed (p_1) and in the poorly developed (p_2) samples at identical developmental stages and phenophases. A considerable difference, however, occured between p_1 and p_2 with respect to both the absolute values of CSD and the architecture. The diversity values of CSD/individual is case of p_1 are very near to each other, contrary to p_2, where in the last time this value is very low.

The NEDLER-type equifinality (cf. O'SVÁTH 1964) between p_1 and p_2 did not ensue even by the ripening of the seed.

A worsening of the environmental conditions (too high temperature and light intensity) was more harmful to p_2 than to p_1.

According to the calculations, one of the causes of variability occuring with regard to the degree of development and the CSD may be the significant weight difference between the fruits produced by the inflorescence of the side umbel and by the main umbel. At germination, at the heterotrophic nourishment stage, the individuals having a lower fruit weight and originating from the side umbels start with disadvantages which in the intraspecific competition affects physiologically (cf. KUROIWA 1960) the development and consequently the CSD. They are also measurable.

Introduction

In the first one of the preceding papers we examined per internode the "effect" of the periodical sowing of anise on the growth parameters, that is, on the relative growth rate (RGR), on the leaf area ratio (LAR) and on the net assimilation rate (NAR) (SZUJKÓ-LACZA — SZŐCS — HORNOK 1975). In the second study we described the architecture (SZUJKÓ-LACZA — SZŐCS 1975).

In the third part of the series of studies, the quantitative analysis of the plant has been dealt with from still another aspect.

In 1974, on the plots sown with anise on the same date, remarkable differences were noticed concerning the growth and little ones with respect to the development of the plants; these manifested themselves also in their architecture.

In order to be able to describe the phenomenon, simple measurements were made at the measuring points and, on the basis of the data obtained, the determination with an approximate accuracy of the current space demand (hereinafter CSD), necessary for the degree of growth of the plant and for its architecture in the given point of time, was attempted.

Further, an answer was sought for the question concerning the cause(s), of plant origin, which affect the variability in the space demand of the individuals in the population, sown at the same time and in the same plot.

Intraspecific competition has for long been an exciting question as regards the natural and monospecific populations and the individuals of the cultivated species (cf. KUROIWA 1960). For measuring the intraspecific competition of plants usually the dry-matter-production differences were used. KUROIWA (l.c.) found significant differences in the respiration measured indirectly and also in the growth parameters and day-time photosynthesis of dominant, transitorial and suppressed individuals of sunflower plots. According to her, the cause of the difference is to be found in the light-conditions within the stand. At the same time she states, on the basis of the dry seed weight and the dry weight of 10-day-old seedlings, that initially the height and weight of the plant are determined by the dry weight of the seeds. BRIGGS—KIDD—WEST (1920) also tested the seed weight differences in *Helianthus annuus* L. when searching for the causes of deviations occuring within the population.

The anise samples (p_1 and p_2) examined at Soroksár in 1974 showed differences with respect to also other characteristics indicating growth. According to a personal communication by L. HORNOK, the differences arose already in germination, and in the appearance of the seedlings at different times.

The architectural elements of the anise — leaves, side shoots, etc. — develop successively proceeding from below upwards, in an acropetalous order (cf. the exomorphic description in SZUJKÓ-LACZA, 1976; and the quantitative analysis of the architecture in SZUJKÓ-LACZA — SZŐCS, 1. c.). Following this, their life time is different. Therefore their position within the stand is also different and according to their localization, temperature-, light-, CO_2 etc. supply, differences may arise among the individual architectural elements. The umbels of the side shoots reach the stage of opening of the petals also at different times. Successively, after the flowering of the main umbel, there follows the lowermost developed side shoot which grows farthest from the main umbel, then the phenomenon can be observed gradually appearing on increasingly higher-lying side shoots. Until the double fertilization ensures in the embryo sac of the ovules, the main umbel presumably inhibits physiologically the full development of the inflorescence lying below it. The inhibition is relieved first on the sideshoot lying farthest from the main umbel. A similar regulation exists in the relation of the side shoots, too. Accordingly, the lifetime of the schizocarps developed on identical plants is also different. Our point of departure for the further investigations was this phenomenon of florescence regulation and its evident consequences. It was supposed that the seedlings might be different also with respect to the initial fruit weight. This does not preclude differences among individuals with mature fruits. The

quantitative differences of the endosperm, i.e. the fruit weight differences, may be the primary cause in the ensuring variability. Therefore, it was examined whether a significant difference can be detected between the differences among individual fruit weights of the main and those of the side shoots of the same plants.

Material and method

The investigations were carried out on "Budakalászi elit" fruit sown in the Soroksár field of the Group of Medicinal Plant Growing, Department of Horticulture, University of Agriculture. The sowing took place on mean-bound, sandy abode soil, in plots of 16 m^2 basic area at 20 cm row distance and at 0.5—1.0 cm stock distance, in three fold repetition. For the preliminary study, samples were selected from the plots sown on 26 March, 1973: 5 specimens were selected on 19 July, 1973; then next year measurements were carried out at variouss phenophases, on the plants sown on 21 March, 1974. For the various times of measurement see Table 1.

In 1974, both fully and poorly developed specimens were available, therefore, on the basis of random sampling, 16 specimens were selected from each of the samples, viz. from the developed (hereinafter p_1) and from the less developed (hereinafter p_2) samples, and the following measurements were taken:

The distance between the apices of the base leaves lying opposite each other, the distance between the third base leaf and the main axes were measured and the mean of the mean of the two values was taken. After the drying off of the base leaves, the diameter of the first internode of the main axis was only measured. Following this, the distance between the two most developed side shoots to be found on opposite sides of each other was measured. The same was repeated by measuring the distance between the next pair of side umbels, and the mean of the two results was taken. This mean value was then the basis for the calculations. Then the height of the specimen m was recorded (Fig. 1). In sample p_1, up to phenophase

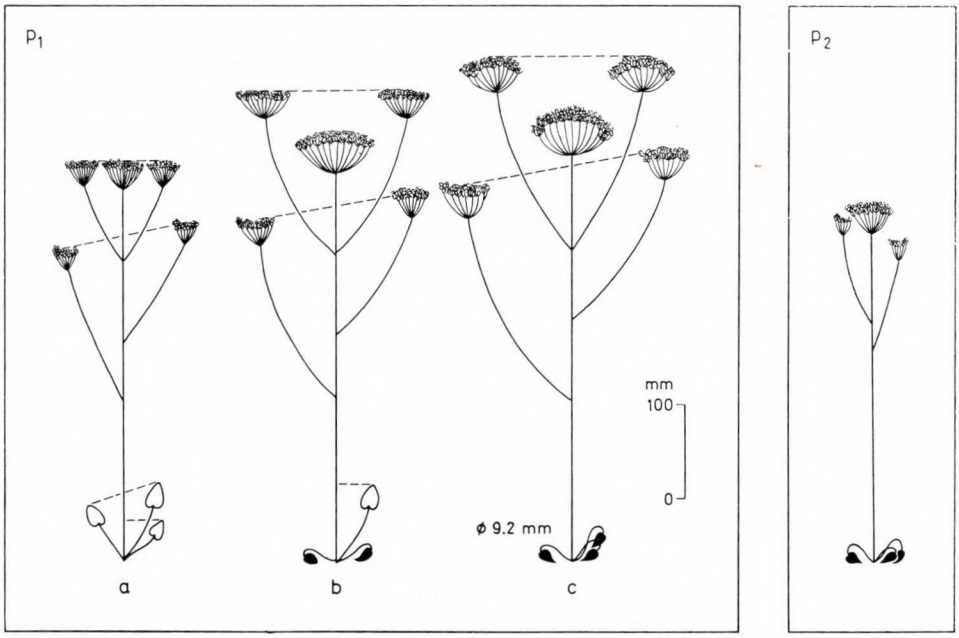


Fig. 1. Measurement points on the plant, at various phenophases

32.2* — that is, when the base leaves and foliage leaves are intact, the secondary inflorescence axes in the umbel of the side shoot are elongated, the umbellets on them are glomerulous, the margin of the petals is light green, the side- shoots are shorter and not yet reaching the height of the main umbel.

The value of m represents the height level from the soil to the surface of the main umbel, while later that of the side-umbels, since the latter overgrow the main umbel.

The height level in sample p_2 was, owing to the under-development of the side-umbels, in every case identical with the height of the main umbel. All of the measurements were carried out with an accuracy of a mm order. On the basis of the data, the space occupied by the individuals can be regarded as a truncate cone. Its volume, that is, the space occupied or filled by the plant, was calculated by means of the equation

$$V = \frac{1}{3} m \pi (R^2 + Rr + r^2) = \frac{1}{12} m \pi (D^2 + Dd + d^2)$$

where V = volume, m = height, $D = 2r$ = mean of distance between two side-shoots, removed farthest from each other, d = mean of distance between leaves of the base leaf rose and the main axis and the third leaf, while later it is the diameter of the main axis. This space demand, necessary within the population at a given time and for individuals of nearly identical developmental stage, was most conveniently called current space demand (CSD), or current space filling (CSF).

The volume of the 16 truncate cones was calculated per sample and per specimen separately, then the mean of the result was taken and related to one individual, and the data were classified. The diversity of CSD was calculated according to SHANNON—WIENER (1963) and equitability after LLOYD—GHELARDI (1964).

In order to answer the second question, 5 specimens of average developmental stage were collected from sample p_1 on 30 July, 1974. Then, in the order of the insertion of the side umbels, 30 schizocarps were collected apically from each of the external umbellets of the side umbels and also of the main umbel. The fresh weight each of the 30 schizocarps was determined separately on the analytical balance, and the data so obtained underwent variance analyses of random arrangement (SVÁB 1967).

Results and discussion

A. The current space demand

Table 1 shows the changes in the measured characters during a given period; the values of m, D, and d behave like two variable functions. In this case, the value expressing the examined growth characteristic can be represented on the y axis as a dependent variable, while t expressing the growth period can be represented as an independent variable on the x axis.

The data and the Figures (Fig. 2) show equally well the differences between p_1 and p_2. It is common for p_1 and p_2, that while the values of m and D belong to the rising period of the curve up to the time of the third measurement, the values of d drop already at the time of the second measurement, in comparison with the first one.

In comparing the frequency values, shown in Tables 2 and 3, with the mean values (Table 1) it can be stated that the individual frequency values

* The code of the stages and phenophases of the ontogenesis is interpreted on the basis SZUJKÓ-LACZA—FEKETE (1973) and SZUJKÓ-LACZA (1976).

Table 1

Mean values of m, D, d, in mm

Sampling time		Life time	p_1			p_2		
Day	Month	in days	m_1	D_1	d_1	m_2	D_2	d_2
21	6	89	433.3	244.4	153.1	227.2	81.8	93.8
01	7	99	490.4	299.2	99.1	349.1	95.4	87.4
16	7	115*	530.9	300.7	9.2	381.1	134.4	5.8**
26	7	125	508.9	298.8	7.6	354.2	98.8	4.2

* Because of the constant, strong wind, the third measurement could take place only after 16 days.

** The value refers only to the first internode, since the base leaves have already dried off.

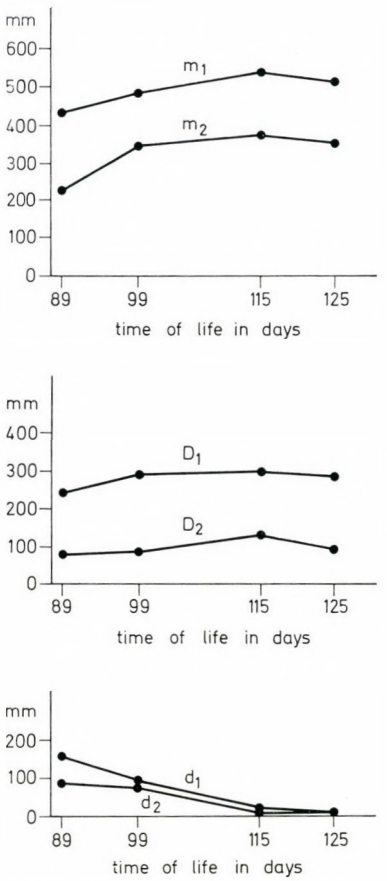


Fig. 2. Changes in *m*, *D* and *d* values in the successive measurement times

of p_1 are the highest around the mean value. In the case of p_2, the individual frequency values could almost excusively be relegated to Classes I and II at the time of the first and the fourth measurements.

According to JUHÁSZ-NAGY (1973) the diversity can be used in a general meaning. In the present case it has been investigated the "represents" on the cubic values frequency (n) in the categories (s) see in Table 2 and 3, where the $N = 16$. It is a time-dynamic approximation of the development and change of the individuals of p_1 and p_2.

Table 2

Frequency distribution of the volume values in the case of p_1 (its class intervals)

Class	I	II	III	IV	V	VI	Date 1974	
dm³	1—5	6—10	11—15	16—20	21—25	26—	Month	Day
	1	2	9	1	3	0	6	21
	0	3	2	6	3	2	7	01
	2	1	7	5	1	0	7	16
	1	5	3	6	1	0	7	26

Table 3

Frequency distribution of the volume values in the case of p_2

Class	I	II	III	IV	V	Date 1974	
dm³	0.1—0.99	1—1.99	2—2.99	3—3.99	4—	Month	Day
	5	8	1	2	0	6	21
	2	3	6	3	2	7	01
	4	6	3	1	2	7	16
	9	7	0	0	0	7	26

Table 4

Change of the CSD diversity and equitability values in p_1 and p_2

Date		p_1		p_2	
Month	Day	Div.	Equitab.	Div.	Equitab.
6	21	1.2771	0.7128	1.1443	0.7110
7	01	1.5160	0.8460	1.5160	0.9410
7	16	1.3335	0.7442	1.4627	0.9088
7	26	1.3940	0.7780	0.6850	0.4256

Table 5

Mean CSD of p_1 individuals by phenophases ($n = 16$)

Date, 1974		Phenophase	CSD in dm³	Diff.
Month	Day			
6	21	21.4.2—23.2; 31.2; 34.2□	13.72	
7	01	21.4.2—23.2; 32.3.4; 35.1—35.3.2; 41.2	17.35	3.63
7	16	22.4—23.2; 33.1.3; 36.1.1—36.1.2; 42.1	13.65	—3.70*
7	26	23.2; 33.2.1; 36.1.2—36.1.3; 43.1	12.85	—0.80

Table 6

Mean CSD of p_2 individuals by phenophases ($n = 16$)

Date, 1974		Phenophase	CSD in dm³	Diff.
Month	Day			
6	21	21.2.4—23.1; 31.1.1	1.55	
7	01	21.2.4—23.2; 31.3.1; 34.2; 41.1	2.45	0.90
7	16	22.4—23.2; 32.3.7; (35.3.4); 42.1	2.24*	—0.21**
7	26	22.6—23.2; 33.1.1.2; (36.1.1); 42.2	0.98	—1.26

* The calculated partial value for the second decade 2.31
** The difference in the calculated partial value for the second decade —0.13

The codes of the phenophases: 21.4.2 — 23.1 = base leaves and stem leaves are developed;
31.2 = The outer and the secondary inflorescence axes are elongated, their umbellets together with the avules are glomerulous, the margin of the petals is light green;
32.3.4 = The anthers have already broken down from the flowers, the petals are dirty white, the disc is high, convex, light-green. The length of the style and the stigma is 1.5 mm; both stigmata have risen above the petals; the bicarpellum is 1.5 mm long and 1.5—1.7 mm wide;
33.1.3 = The fruit has reached its full length: 3.5 mm long and 3 mm wide.
The fruit is ripening 33.2.1 = its colour in the furrows is brownish, on the ribs yellowish, the whole is of a greyish-brown hue, the two carpels separate from each other when slightly pressed;
34.2 = the side umbel corresponds to state 31.2 of the main umbel;
35.1—35.2 = In the inflorescence of the side umbel, the petals are spreading out, the stamens are extended upwards, the style is as high as the petals;
36.1.1 = Most of the petals have dropped from the flowers of the side umbels, the styles — if still visible — are of a watery colour, or are drying off, the length of the bicarpellum is 2.5—3 mm, its width 2 mm;
36.1.3 = On the side umbels the fruits are developed, but still greenish grey;
41.2 = The first base leaf has dried off;
42.1 = The three base leaves have dried off;
43.1 = The four stem leaves have dried off.

The maximum diversity and equitability values are noted both in p_1 and p_2 also in blooming time of 1st July (Table 1) but in in case pf p_2 the first and third values are also very near to each other and maximum. Contrary

to p_2, which shows very low values because the representatives are divided only into two categories (the first and second), p_1 remains near the same level of the last measure time.

On the basis of a comparison between the values of Tables 5 and 6 it can be stated that the individuals of samples p_1 and p_2, sown at identical times, are at different phenophases during the whole period of growth. The more developed specimens possessed full foliage already at the initial phase of the experimental period, the petals neared blossoming on the main umbel. On the specimens of samples p_2 the main umbel has just appeared on the apex of the main axis, while the uppermost stem leaves, together with the internodes, were still growing. The differences appear beyond the deviations in phenophases, in the strong (p_1) or poor development (p_2) of the side-shoots, and in most cases, even in the lack of the side-shoots with regard to p_2 (see the phenometric signs and their code in parenthesis in Table 5). The side-shoots of the individuals in p_1 overgrow the main umbel, and also the fruits develop on them. On the individuals of p_2, the side-shoots dry off early, or if they persist, they finish their growth on the level of the main umbel, they are short, their expansion is small, their number two at most. According to these observations, in *Pimpinella anisum* the quality of the side-shoots determines the CSD to a great extent.

A common characteristic of both samples is that there is a maximum value in their CSD (Tables 5 and 6), which occurs when the base leaves still — at least partly — exist, the main umbel is at blossoming and at the same time the side umbels are already considerably developed. At the time of the CSD maximum, the plant possesses its largest surface of assimilation and, as a result of transpiration and respiration as well (cf. SZUJKÓ-LACZA—SZŐCS—HORNOK, l.c). This fact involves an increase in the demands which the plant raises in relation to its environment, in accordance with its daily endogenous rhythm and speed, certain elements of the environment are built in by the plant.

The decrease after the maximum of the CSD is a consequence of the disorganization of the base leaves, and of their eventual drying off. The chlorotic phenomenon of the leaves starts already before the complete drying off, therefore they are inactive as regards assimilation.

With the drying off of the base leaves, the truncate cone shape expresses the CSD changes strongly, since the value of d represents the width of the first internode only.

At the next measurement this value still increased a little, owing to the thickening of the internode, then this was followed by a drying off process which influenced the width of the first internode as well (cf. Table 1). In sample p_1, after the maximum, the CSD decreased gradually, while in p_2, during the last 10 days that had passed between the third and fourth measurements,

it decreased abruptly. This may partly be in connection with the circumstance that during these 10 days the daily mean and maximum temperature values were also high.

NEDLER and his co-workers (cf. O'SVÁTH 1964) were the first to study the non-additive reversible and irreversible effects in growth under varying conditions. It seems that by measuring the CSD parameters at the time of the fourth measurement, an irreversible environmental effect complex, negatively influencing the trend and rate of growth in the plant, became enumerable. As a result of this effect, the equifinality which was still expectable earlier did not ensue on the individuals of p_2. According to NEDLER, in such cases under too rough effects — obstacles — regeneration is impossible, the state of irreversibility arises (cf. O'SVÁTH 1.c.).*To sum up: The individuals of *Pimpinella anisum* possess a current space demand linked with their developmetal stages and phenophases, this is measurable and undergoes changes depending partly on the state of development of the plant and partly on the external conditions.

The CSD maximum is reached by p_1 at the phenophases characterizable by the decimal numbers 21.4.2 – 23.2; 32.3.4; 35.1—35.3.2; 41.2; while in the case of p_2 by 21.2.4 – 23.2; 31.3.1; 34.2; 41.1. The maximum is preceded by the gradual decay of certain base leaves which are the oldest and at the same time the nearest to the surface of the ground.

The maximum space demand may be different even in plots of identical sowing time, and the difference may became stabilized also by the circumstance that the external conditions preclude equifinaly to ensue. According to Tables 4 and 5, in anise samples p_1 and p_2 grown under changing conditions, the NEDLER-type equifinality did not ensue in the characteristics examined, which is attributable to the circumstance that in the plants of different phenophases unfavourable effects (presumably the too high temperature and its indirect effects) influenced architectural elements extant in various physiological states. This explains why the damage to p_2 individuals was stronger than that incurred by p_1 ones.

Remark: On the basis of the results, the preliminary estimation of the CSD in cultures is recommendable also for the selection of the phenophase to yield maximum production or maximum productivity. By taking the CSD into consideration in this way, the realization of the nearly complete potential of the species is expectable if also the initial and external conditions are favourable.

* Mention should be made here of the errors affecting the results. Here belong the errors occuring in sampling, in categorizing the individuals into p_1 and p_2; the possible injuries to the individuals measured during the experimental period, and also the small-scale inaccuracies of the measurements. Besides, it should be taken in consideration that, following from the architecture of the plant, the space thus calculated is not densely filled in by the specimens, because the side shoots of the neighbouring individuals may invade those of the others.

B. Fruit weight examinations

According to the result of the analysis of variance, the weight of the fruit developed on the main umbel differs from the fruit weights of the side shoots originating from nodes 5, 6, 7 and 8. (The side umbels originating from

Table 7

The fruit weight variability of Pimpinella anisum L., on the basis of 30 fresh fruit weights of each of the main umbels and side umbels of 5 p_1 individuals

Treatment node of the shoot	Node	Repetition					
		1	2	3	4	5	x
1	Main umbel	.2450	.3152	.2953	.2857	.2853	.2850
2	5	.2299	.2306	.2149	.1239	.2219	.2040
3	6	.1551	.1831	.2250	.1569	.2747	.1970
4	7	.2651	.1356	.1956	.1628	.2513	.2020
5	8	.2157	.2655	.1954	.1628	.2060	.2090
6	9	.2351	.2500	.2655	.2147	.2629	.2460

Table 8

Analysis of variance of the results

Factor	SQ	FG	MQ	F = .0035
Treatment-node of the shoot	.0303	5	.0061	
Error-remainder	.0401	24	.0017	
Total	.0704	29		

Table 9

Mean values of the fruit weights (in diagonal), their differences (in the right upper matrix), and the significance levels

Treatment	1	2	3	4	5	6
1	.285	.081	.088	.083	.076	.039
2	**	.204	.007	.002	.005	.042
3	**		.197	.005	.012	.049
4	**			.202	.007	.044
5	**				.209	.037
6						.246

** $p \leq 1\%$

nodes 3 and 4 were not intact in every specimen, therefore they were omitted from the analysis.)

However, the average weight of the fruits developed on the side umbels, independently of their node number, do not significantly differ from one another The weight values of the fruits in the side umbels originating at node 9 are fairly near to one another. Regarding their localization, these side umbels are nearest to the main umbel (in certain specimens they origin at a common node).

According to our anatomical observations, most of the fruits which developed on the first-order side shoots containing the embryo and the endosperm storing the secondary nutrient materials. It is probable that the difference between the main umbel and the side umbels derives from the quantity of their endosperm.

On the basis of the results it is presumable that the difference between p_1 and p_2 might be related already at the period of germination also to the fruit weight differences originating from the architecture of last year specimens with mature fruits. This, in turn, involves that there are quantitative differences in the utilizable reserve nutrient materials at the stage of germination and that of the heterotrophic nutrition.

To this initial situation, the consequences of further unfavourable external conditions may accrue (see the developmental deviations among the individuals), as a result of which the differences become "stabilized". Therefore, KUROIWA's statement (l. c.) is justifiable, it is, however, to be completed in that the intraspecific competition among the developing or developed individuals is itself already a consequence. On the other hand, among favourable external conditions equifinality may ensue, in which case the intraspecific competition within the population does not cause heterogeneity to a remarkable (that is significant) extent. (In natural stands the distance between the seeds lying on the ground is different; there the excessive proximity among the seedlings may increase competition to actual selection.)

The results of BRIGGS—KIDD—WEST (l. c.), of KUROIWA (l. c.), and my own results, underline (from the point of view of breeding) the importance of the reserve nutrient quantity accumulated in the endosperm and of the seed (fruit) selection according to weight.

With respect to the anise it can be stated finally, that the variability of the individuals sown at identical times — indicated in CSD, and the differences detectable separately in other characteristics measured concurrently — might be related with the initial fruit weight differences as well. And this latter depends on the localization of the fruits.

REFERENCES

BRIGGS, G. E.—KIDD, F.—WEST, C. (1920): A quantitative analysis of plant growth. Part I. Ann. appl. Biol. 7, 103—123, II. 7, 202—223.

JUHÁSZ-NAGY, P. (1973): A növényzet szerkezetvizsgálata: Új modellek 2. rész. Elemi beskálázás a florális diverzitás szerint (The structure of vegetation: New models part 2. Elementary scaling and floral diversity.) Bot. Közlem., 60, 35—41.

KUROIWA, S. (1960): Intraspecific competition in artifical sunflower communities. Bot. Mag. Tokyo, 73, 330—309.

LLOYD, M.—GHELARDI, R. J. (1964): A table for calculating the 'Equitability' component of species diversity. J. Anim. Ecol., 33, 217—225.

O'SVÁTH, J. (1964): Növényi növekedések matematikai meghatározása (Mathematical determination of plant growths). Magy. Tud. Akad. Agrártud. Oszt. Közlem., 23, 113—134.

SHANNON, C. E.—WEAVER, W. (1963): The mathematical theory of communication. 117 pp. Univ. Illionis Press, Urbana.

SVÁB, J. (1967): Biometriai módszerek a mezőgazdasági kutatásban (Biometrical methods in agricultural research). Mezőgazdasági Kiadó, Budapest.

SZUJKÓ-LACZA, J.—FEKETE, G. (1973): Synphenological changes in the vegetation of submediterranean oak forest (Orno-Quercetum). Ann. Hist nat. Mus. Nat. Hung., **65,** 127—146.

SZUJKÓ-LACZA, J. (1976): Az ánizs Pimpinella anisum L. (Anise, Pimpinella anisum L. In press.)

SZUJKÓ-LACZA, J.—SZŐCS, Z.— HORNOK, L. (1975): LAR, NAR RGR perameters internodially, and crop volatile oil yield in Pimpinella anisum L. sown periodically. Acta Bot. Acad. Sci. Hung., **21,** 175—188.

SZUJKÓ-LACZA, J.—SZŐCS, Z. (1975): The architecture and the quantitative investigation of some characteristics of anise Pimpinella anisum L. Acta Bot. Acad. Sci. Hung. **21,** 443—450.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 22 (3—4), pp. 475—481 (1976)

RECENSIONES

A. LÖVE and D. LÖVE: Cytotaxonomical Atlas of the Arctic Flora, Vaduz, CRAMER Verlag, 1975, 598 pp.

I reviewed the 'Cytotaxonomical Atlas of Slovenia' by the LÖVEs in Acta Bot. Acad. Sc. Hung. 21: 452—453 (where 122 is a printing error for 1242 pp.). The structure and aim of the new book is similar, therefore, I refer to the former review. The area included in the Atlas is many times greater: Iceland, the Arctic Ocean coast of Europe, Arctic Northern-Asia and North America, Greenland. The flora is however much poorer, thus the work also discusses only fewer species. These, on the other hand, are endemic partly in our country as well (many monocotyledons), therefore the data are interesting also for us. The taxonomical and nomenclative elaboration is the most up to date, the only thing is that the authors go too far, now even more, in the breaking down of the genera. The *Pseudorchis* is correctly *Leucorchis* all the same, because it is nom. illegit. The lay-out of the book is perfect.

R. Soó

CZEREPANOW, S. K. Additamenta et corrigenda ad "Floram URSS" (tomi I—XXX). — Leningrad 1973, 668 pp.

The large Soviet Flora work was closed with Volume 30 in 1964; in the same year a register volume was published (for review cf. Bot. Közlem. 52, pp. 179—180).

The volume on Soviet Flora discusses 17520 species, however, by using a rather narrow species conception; the so-called KOMAROV-type species in a Western interpretation qualify partly as subspecies or microspecies. CZEREPANOW's introduction, which is given in Russian and English, furnishes the information that on the basis of the newer researches 1080 species have been placed in a category of lower systematic value, while 1290 'species' have been placed into synonyms, and about 520 species have been placed back. Thus, at the closing of his work, the author estimates the species number of the plants of higher order of the Soviet Union as 21,000. The name of more than 1030 species has been changed, while the name of 7180 taxa has been corrected. It can already be seen by means of these few numerical data how important this work is not only with regard to the Soviet flora but also as far as its Hungarian implications are concerned.

The discussion of the taxa (going down to subspecies) is arranged according to the alphabetical order of the families; the valid new names are emphasized by bold type-faces; but very many new combinations and synonyms are also included. In the case of the taxa which are discussed often, the complete synonyms are compiled and an ample literature is also provided. According to the enumeration of the main sources on pp. 20—23, from the Hungarian literature the handbooks of Acta Bot. Acad. Scient. Hung. (up to 1970 as in in general the periodicals) of SOÓ—JÁVORKA (1951); and of SOÓ (1964—70) were used, and also SOÓ's series entitled Species et combinationes novae (1—8), but as it turns out of the text, other Hungarian papers were also taken into consideration, and their inferences were overwhelmingly accepted. In the Supplement even such a questionable name is accepted as the *Lilium martagon* L. subsp. *sooianum* PRISZTER 1967. Our ash, which was mistakenly united with with *Fraxinus oxycarpa* in the Flora Europaea, is now correctly named as *F. angustifolia* subsp. *pannonica* SOÓ et Simon. We cannot go into further details, and on the other hand we cannot complain

about that the data of the Carpathian Ukraine, hidden in the Hungarian and Czechoslovakian literature, are partly missing, while from my *Ranunculus auricomus* agamospecies (Soó 1965—1965) even such as originate from other places are included. The elaboration of the genus *Rhinanthus* in the Flora of the SSSR is corrected also on the basis of my paper from 1970.

I must admit, it satisfies me that the author—like the authors of the new Flora Evropeiskoi tchasti USSR (of which so far Vol. *I*, 404 pp., *Pteridophyta, Gymnospermae, Poales*, 1974; and Vol. *II*, X + 236 pp., *Orchidales, Juncales, Cyperales* 1976 have been published; editor-in-chief A. FEDOROV)—is in opposition to the trend, represented today especially by BOBROV, which sticks to the KOMAROV-type species conception. KOMAROV and his school accepted only the monotype species as an indivisible, homogeneous taxon (this definition is proper only with reference to the genetical biotype). As a consequence, the authors of the Flora of the USSR did not include the infraspecific taxa, several subspecies, ecotypes, and they even discussed hardly different forms as species. In this field, especially the authors of the Ukrainian flora went too far; no wonder that in the Flora Europaea, and also in my Synopsis a considerable part of these "species" is classified as a synonym (as against BOBROV cf. the analyses of SKORTOZOV, 1972). The aforementioned new European Soviet Flora represents the modern taxonomical conception in this field. (In that, SMOLYANINOVA discusses the *Orchidaceae* entirely on the basis of my paper of 1969, surveying the orchideae of the Soviet Union; Ann. Univ. Budapest, Sect. Biol. *11*, pp. 53—74, 1969).

The flaw of the work is that occasionally taxa which belong to the same genus can be found classified to another genus and vice versa.

It is a pleasure for us to acknowledge that our Soviet colleagues satisfactorily take the works of Hungarian authors into consideration and at the same time we point out how important the above works are for us.

R. Soó

TÜXEN, R. et collab. Bibliographia Phytosociologica Syntaxonomica. Lief. 19—28. Verlag J. CRAMER (Lehre, z.Z. Vaduz)

In dieser Zeitschrift habe ich einmal ganz kurz (Acta Bot. Acad. Scient. Hung. 17 : 464), einmal ausführlicher (20 : 207—211) 1974 die große Unternehmung von TÜXEN, die syntaxonomische Bibliographie, in englisher Sprache, besprochen. Wesentlich gilt alles, was ich früher schrieb, auch heute. Vernachlässigung der Literatur Osteuropas, viele Fehler in Einteilung der einzelnen Assoziationen in die verschiedene Klassen, ungenaue Zitate (dafür habe ich nur aus 5 Lieferungen eine lange Reihe aufgeführt, l. c. 209—210) sind leider auch in den neueren Teilen zu finden. Dagegen ist aber das ganze Werk wirklich monumental und unentbehrlich. Für Ungarn und seine Nachbarländer sind unter den neuen Lieferungen besonders jene von großer Bedeutung, die gewisse Klassen und Gesellschaften der Ruderalpflanzen (*Artemisietea, Onopordetea, Plantagineetea*), die Gebüsche (*Rhamno-Prunetea* zu weit gefasst, die Karstbuschwälder: *Orno-Cotinetalia* gehören bestimmt nicht dazu), die Weichholzauen (*Salicetea*) und die Moorwälder (*Alnetea*) behandeln. Oft wurden manche, von ungarischen Autoren beschriebenen Einheiten fremden Verfassern zuerkannt. (z. B. *Glycyrrhizetum echinatae*!). Vollständiger Unsinn ist es, einen Teil unserer Sumpf- (»*Agrostion albae*«) und Salzwiesen (»*Juncion gerardii, Beckmannion*«) in die nitrophilen Ruderalgesellschaften der *Plantaginetea* einzureihen. TÜXEN hat vollständig Recht, wenn er (als Erwiderung der Kritiken) im Vorwort der 25. Lieferung schreibt: Demnoch glauben wir, daß das Ganze eine nützliche Grundlage für alle Bearbeiter der angeführten Gesellschaften bildet.

Die neueren Lieferungen (1973—1976): 19. *Isoeto-Nanojuncetea*, 20. *Nardo-Callunetea*, 21. *Artemisietea vulgaris*, 22. *Onopordetea acanthii*, 23. *Rhamno-Prunetea*, 24. *Trifolio-Geranietea*, 25. *Salicetea purpureae*, 26. *Alnetea glutinosae*, 27. *Polygono-Poetea annuae*, 28. *Plantaginetea mioris, Agropyretea*.

R. Soó

JÁVORKA, S., CSAPODY, V.: Iconographia florae partis austro-orientalis Europae centralis (Iconography of the flora from the South-eastern part of Central Europe); 40 coloured plates and 576 pages with 4090 drawings. Akadémiai Kiadó, Budapest 1975, $85.—

Akadémiai Kiadó has rendered botany a service of paramount importance when — fulfilling a demand of many decades — it re-issued the magnificent work entitled Iconographia Florae Hungaricae by S. JÁVORKA and V. CSAPODY. The original volume was published in leaflets, between 1929 and 1934, as a joint publication of the Hungarian Natural Science Society

and the "Studium" Publishing Corp. — The original edition can be considered as the illustrated volume of Sándor JÁVORKA's work of the Hungarian Flora (Flora Hungarica, 1924—1925). While the Iconographia was being published, Sándor JÁVORKA (1883—1961) was section head, later the director, of the Botanical Department of the Hungarian National Museum. The large number of drawings and paintings are the work of Vera CSAPODY, second to none in this artistic and botanical achievement, and she produced the drawn-to-life pictures under JÁVORKA's guidance. (Carefully selected exemplars deposited in the very rich herbarium of the Botanical Department of the Hungarian Natural History Museum were used as models for the drawings and paintings.) Most of the drawings depict plants in their natural size; reduction of the colour paintings is 2/3.

It was incumbent on the two co-workers of the new edition, dr Rezső SOÓ, academician, and dr Szaniszló PRISZTER, botany garden director, to carry out on the one hand the necessary alterations in nomenclature — arising during the more than four decades which elapsed since the first edition — and to provide taxonomical supplementations (this part was R. SOÓ's contribution, who also wrote the foreword), and on the other hand to compile a glossary for the English-speaking reader, to arrange the indexes, and to give an explicative summary (this part was Sz. PRISZTER's contribution, also the editor of the new edition). All these are given on 73 pages at the beginning of the book. In connection with the taxonomical and nomenclatural corrections, the invalid and the incorrect names (species and infraspecific taxa) are collected in a long list (24 pages), under the currently valid names. Since in the original Iconographia, which had at that time been issued for four and a half years, several new combinations were published, the detection of the date of publication with respect to the various leaflets was most important; the collation of these bibliographical data was also Sz. PRISZTER's work. The voluminous trilingual (Hungarian-Latin-English) dictionary of the technical terms and the list of geographical names are of great practical use in the introductory part, which closes with a survey of the plant families and their index.

The illustrations of the new edition were taken from Vera CSAPODY's original watercolours and washdrawings (which survived World War II, and which were used in the first edition). On the plates of drawings, in comparison with the original, only small technical corrections have been carried out.

Although in the last three decades there were published several floral works containing plant illustrations from the neighbouring regions, no other atlases with a claim to completion with regard to the Pannonian, Illyric and Croatian-Mediterranean flora are avaibale even today than the Iconographia by JÁVORKA and CSAPODY. This volume is therefore an important source work for both home and foreign botanists. Its practicability has been greatly increased by the modernization accomplished with respect to taxonomy and nomenclature.

Thanks are due to the Akadémiai Kiadó for this noble enterprise. The reputation of the Akadémiai Nyomda will be raised by both the technically and aesthetically perfect layout of this master work.

G. FEKETE

SZABÓ, T. E. A.: Szerkezetek és rendszerek a növényvilágban (Structures and systems in the world of plants). "Kriterion" Könyvkiadó, Bucharest 1975, 203 pp. (5.25 lei)

This volume of pocket-book form, with 17 very illustrative drawings, 10 plates of various tables and with several surveys presenting certain interconnections, has been published as the recent issue of the series entitled "Korunk Könyvek" (Books of our Age), launched in Bucharest in 1972. The editors of the series, Ádám DANKANITS, Gusztáv MOLNÁR, T. E. Attila SZABÓ, and Tibor TÖRŐ, started their work with the aim of achieving, book by book the promotion of a continual deepening of the intercourse between man and science, the approach and understanding of new phenomena, notions and recognitions which arise at an ever-increasing tempo. In a like manner, they should facilitate the comprehension of the basically important interconnections; in addition the books should give evidence on the tasks confronting the views of the man of future, as well as on "the biological, social and economic conditions of the intellectual and physical development of man, and they should deal with the furnishing of information and of culture, and with the communal, moral and professional responsibility of scientific research."

In the explanatory note on the backcover of the booklet, the author states that "it emphasizes the claim of establishing a unified botanical attitude which preserves the values of the past but also looks towards the future; in order to present the inter relationship between man and plant — which in certain cases have assumed vital importance in a strict sense of the word — the drawing of a parallel between traditional and new attitudes of systematization

has been used as framework." This indeed is apparent from the whole treatment of the subject. However, something else must also be emphasized which is not revealed even by the title of the book, but stressed in the introduction and given application in the following chapters in several places namely wherever it is possible "to make perceptible" the unity of structure and operation spanning over the organizational phases. In addition to the endeavour of reaching a modern attitude and throwing light on the interconnections, the value of the work is undoubtedly increased by the fact that not only are there several theoretical examples but also practical data originating from recent years, which shedlight to a satisfactory extent on the interrelationships between man and plant and at the same time not only comply with the demand of the wider interest and curiosity of the reader but also increases them.

The book is composed of an Introduction and of six chapters; within the chapters there are sections and sub-sections with decimal numbers of first and second orders. Each chapter is introduced with a motto taken over from various noted scholars.

Chapter 1 bears the title of *Man and Plant* and after a historical retrospect and a chronological table supplementing it (embracing the period from the 5th millenary b.o.e. to 1969) there are treated, in a separate sub-section, the interrelations, regularities and developmental trends preavailing in the biosphere, and the researches into these as well as the practical applications of the research data.

Chapter 2, entitled *Structure and Operation*, treats in a completely new conception: the so-called system-centred approach — independently of the idea and category classification of the classical, static systematization of formal character — the question of dynamic systematization, structure and operation, emphasis being given to the realization of metabolism, information supply and energy turnover. Within the sub-section entitled "The system of the cell" the book deals with the molecular systems of the cell, and on an electron-microscopic level with the system of cell organs, while, on the other hand, within the sub-section "Cell systems, tissues, organs", with the formation, form maintenance, nutrient uptake, assimilation and dissimilation as well as with secondary plant substances. The following sub-section has practical implications (for example, our natural springs, organic matter production of the phytosphere, cultivated plants, controlled agricultural organic matter production).

Chapter 3, "*Preservation and Development*", consists of two sub-sections. One of them discusses information carriers (nucleic acids, genes, chromosomes) and information flow (changes in information, macro- and microevolution). The other sub-section discusses the practical aspects of the former, as the questions of cultivation gene-stock, gene-reserves and gene-bank.

Chapter 4 analyses the subject of "*Classification*", mentioning the importance of perspectives in the method of electronic data processing. It also touches upon the historical changes and development in aims and methods, the successive solutions, the traditional species concept, the expanding of the species concept, the modern interpretation of the plant individual, and finally on the role of systematization satisfying practical demands.

Chapter 5 discusses "*The Interrelations of Species*" and refers to the contact (for example parasitic) and transbiotic interrelations, to the allelopatic effects, and finally to the interrelation-system manifesting itself increasingly more forcefully in the biosphere. In the remainder of the sub-sections we can read about interesting and original analyses, in the species, in the plant association, plant community and environment. The classification of plant associations, production, succession and practical aspects.

Chapter 6, "*On the analysis of the system*", provides information in very clear wording on historical aspects, on the interpretation of the system theory, on the methods of system analysis, on the changes in status occuring in the system, on data processing, on the introduction of computer techniques, on its possibilities of their advantegous application, on programming and finally on the practical implications. This well-constructed chapter, emphasizing essentials, convinces us — to quote the words of the author — that the main trend of development in system analysis is indicated by the methods developed by the use of computers, methods which necessitate beyond the learning of a new method also the acquisition of a new way of thinking.

The chapters here reviewed are well supplemented with some appendix-like compilations, as, for example, the index of names, of Latin plant names, of Hungarian plant names, the subject index, the list of figures and of tables, and of the 26 textbooks and special books published during the last 8 years, and finally, the easily surveyable table of contents.

We can recommend this up-to-date work, containing stimulating analyses, rich in theoretical and practical information, and of an attitude indicating development, to every botanist and to every other specialist interested in the subject, to young and old teachers of botany, and to university students.

S. SÁRKÁNY

LORIN W. ROBERTS: Cytodifferentiation in plants xylogenesis as a model system. Cambridge University Press, Cambridge—London—New York—Melbourne. 1976, 160 pp.

The author of this study presents a rewiev of the results achieved in tissue cultures, one of the most exciting fields of experimental biology today. Almost independently of the starting material, the most remarkable in plant tissue cultures is the formation of the xylem elements. The sub-title indicates this.

The study is not concerned with the systematically ordered investigations between tissue cultures (e.g. the biologically more or less determining systems) or species, but with the effects of the various hormones inducing growth and cytodifferentiation, or, for example, the effects and results of chemicals inhibiting the activities of these hormones, with the connection between nutrients and environmental factors and so on.

Auxin, cytokinin, gibberellins, ethylene, adenesin 3',5'-cyclic monophosphate are plant hormones applied most frequently as agents to induce growth and differentiation in the culture. The study reviews in detail the results obtained so far in either separate or collective or sequential application of these hormones. The author also contributed to this chapter as a research worker, with her own investigations.

One of the most interesting chapters treats the question of the various states of cell cycle, by dividing them into four stages — (i) before DNA synthesis, (ii) during DNA synthesis, (iii) before mythosis, (iv) during mythosis — and pays, among others, special attention to endopolyploidy.

According to the author, only relatively few experiments can be evaluated, owing to technical and interpretative difficulties from the viewpoint of the effects of environment on tissue cultures. Nevertheless, the existing results point out the regulating role, to diverse extents of the effects of water, water-pressure, temperature minimum and maximum, O_2, CO_2, light, ozone, as well as that of electromagnetic and mechanical effects on the differentiation of the several tissue elements or indeed on that of whole organs.

In Chapter 10, an epilogue according to the author, a summary of results unconnected with (or not only with) the differentiation of transporting elements is given.

The author gives the synthesis of his own opinion or of current problems in the form of questions or meditations occuring in the various chapters, thereby indicating, as it were, the experimental trends required.

The 600 items of literature considered by the author provide a picture up to 1974 of the most important results of the field in the English languages. As a result of the large number of the literary data, local repetitions occur and to a smaller extent also problems of construction arise in this book.

The material of drawings and photographs as well as the typographical lay-out are of high grade.

The book may be recommended for use in the fields of research and teaching.

J. SZUJKÓ-LACZA

I. M. SZABÓ: Microbial communities in a forest-rendzina ecosystem, The pattern of microbial communities. Budapest, Akadémiai Kiadó 1974.

This still young branch of microbiology, soil microbiology, in Hungary, is represented by about eight hundred scientific works. In spite of the small number of soil microbiologists, the past eight decades have been an age when the "Soil microbiological school of Sopron" founded by D. FEHÉR had an international lead in this field. One of the members of this school is the author of this book.

The results and of course the conclusions of twelve years of research carried out and supervised by the author with the help of his coworkers Mrs M. SZABÓ and I. BUTI and other specialists of zoology, biochemistry, pedology, computer science are contained in this comprehensive book of 415 pages.

The original research data are discussed in the light of the international literature: 560 references are quoted of which 10% were published by Hungarian scientists including the thirty-seven papers published by the author with his coworkers.

The results are demonstrated and well-illustrated with 58 tables and 91 excellent figures. There are seven chapters and the appendix: List of authentic cultures is included in the taxonomic investigations (about three hundred strains: actinomycetes and bacteria).

Chapter *1.: The forest-rendzina ecosystem. General description, 2. Micromorphological and microecological investigation of the humus A) horizon, 3. Hydrothermic conditions and micro-*

bial growth, 4. Composition and properties of the actinomycete flora, 5. The role of the larvae of St. Marks fly in soil formation and their influence on soil microorganisms, 6. Studies on the rhizoplane microflora of black locust (Robinia pseudoacacia) seedlings, 7. The pattern of microbial communities.

This monograph may be characterized generally as a modern microbiological-ecological work with special new conceptions, the problems emerging are discussed precisely and from many aspects (as the titles of the chapters themselves indicate).

The detailed and multilateral investigations aimed at discovering the fundamental pattern of community organization is supported by a high-level taxonomic analysis, especially on the actinomycetes. The methods used are suitable for approaching those questions which the author aimed, to answer. The language and style are good, the text is concentrated but clearly understandable for those readers also who are less familiar with the English language.

Undoubtedly, it would have been better to collect this vast information synchronously, however, for this not only a team would have been needed but a huge institute to work on it.

With respect to Hungarian soil microbiological research: this book certainly provides information for a better knowledge and understanding of the "natural" terrestrial ecosystems, on the life of the forest soils and soils at all. Moreover, with the general concludions it promotes the development of microecology. In addition, the achievements of one of the sections of the present soil microbiological research in Hungary are summarized.

It is hoped that this work will have the same success among scientists all over the world as that of the Master: (D. FEHÉR: Untersuchungen über die Mikrobiologie des Waldbodens. Berlin, Springer Verlag, 1933) in its age.

This book could be recommended for soil microbiologists, microbiologists, specialists in taxonomy (actinomycetes), specialists primarily in the terrestrial ecosystems, but in any field of ecology, pedologists but also to those working in different fields of biology (e.g. botanists and zoologists) forestry and agricultural sciences both in research and teaching.

The Publishing House of the Academy of Sciences: Akadémiai Kiadó deserves special praise for this beautiful presentation.

M. KECSKÉS

R. K S. WOOD and A. GRANITI (editors): Specificity in Plant Diseases. Plenum Press, New York and London. 1976, 354 pp.

This book is volume 10 in the Series A: Life Sciences of the NATO Advanced Study Institute Series, and contains the papers presented on the interactions that determine the specificity characteristic of diseases of higher plants caused by fungi and bacteria. Virus diseases were not treated in this Symposium, which was held in Alghero (Sardinia), Italy, May 4—17, 1975. In addition to the plant pathological papers, R. C. HUGHES presented a lecture on animal membranes as recognition sites and H. F. LINSKENS on specific interactions between higher plants. He also discussed the analogy between incompatibility and immunology and has shown analogies between the infection processes in plant diseases and the incompatibility reaction in the fertilization of higher plants.

This excellent volume contains presentations by world-renowned specialists in their fields with critical reviews and provocative conceptions. After each presentation a number of contributions are given but only in titles. A synopsis of contributions and discussions is given after each presentation by the chairman and discussion leader of the session.

Following the opening address by A. CICCARONE, the phenomenon of specificity in plant disease was discussed by P. W. BRIAN (Cambridge). HEATH investigated the stages during rust infection at which specificity may be determined. OUCHI pointed out that host cells conditioned by pathogenic races or species are subsequently unable to recognize the incompatible or non-pathogenic mildews as foreign entities and permit successful infection. A. GRANITI discussed tissue and organ specificity in plant diseases, emphasizing the lack of knowledge in this field.

JOHNSON lectured on the genetics of host—parasite interaction and the summary on the discussion was given by ELLINGBOE. Peter DAY discussed the gene functions in host—parasite systems from the point of view of the induced susceptibility hypothesis and the discussion comments and contributions were summarized by PERSON. Following the lecture by HUGHES on animal cell surface membranes as recognition sites, four were concerned with the existence of recognition sites for infectious plants pathogens. ALBERSHEIM's report on cell surfaces and the biochemistry of varietal specific pathogenesis was essentially the same as has been published in Ann. Rev. Plant Physiol. 26, 31—52. 1975. His hypothesis on the inducers (elicitors) of phytoalexins stimulated much discussion. SCHEFFER stated in his summary that there were

doubts that this hypothesis would lead to an understanding of host specificity in plant pathogens. In two papers CALLOW discussed the possible role of lectins in recognition and defence in plants. Evidently, more data are necessary to evaluate the role of both "elicitors" and lectins in specific host-parasite interactions. RUDOLPH on the interaction between plants and bacteria pointed out that it has not been demonstrated with certainty whether a few dead plant cells are the cause of the resistant reaction or a secondary response. The paper of BUSHNELL on reactions of cytoplasm and organelles elaborated on the recent knowledge on papillae formations and on the role of haustoria in disease resistance. DALY was thought provoking with his induced susceptibility hypothesis as exemplified with rust disease. According to this, hormonal changes are causative factors in determining host-parasite specificity. He speculated on resistance that develops if a metabolic switch is not turned on, and suggested that hormones may trigger each switch in susceptible plants. Incompatibility may not involve an active, positive process or mechanism controlling the pathogen. There are situations where parasites simply do not have the proper environment for development. He attacked the hypotheses on the role of activation of protein biosynthesis, formation of antifungal compounds (toalexins) and hypersensitivity in disease resistance. TANI's paper was of special interest. He concluded that senescence rather than juvenescence promotes rust uredospore formation in oat leaves. ROHRINGER on the involvement of nucleic acids in host-parasite specificity, considered that the compounds that determine the resistant reaction (in fact, the hypersensitive reaction with tissue necrosis) in wheat to stem rust is presumably RNA. This hypothesis was seriously debated by the session. DEVAY summarized the data available on the protein specificity in plant disease development. The possible role of agglutinins (lectins), and common antigens (protein sharing) was stressed. WHEELER summarized the new advances on phytotoxins and criticized the results from STROBEL's laboratory on the specificity of *H. sacchari* toxin. DALY's comment was also critical but ALBERSHEIM and STAPLES spoke in support of STROBEL's work that the toxin acts by binding to the protein in membranes of the susceptible host. It was unanimously accepted that, if STROBEL's evidence is confirmed, it will provide for the first time at the molecular level, a specific mechanism for virulence in the pathogen and a specific mechanism for susceptibility in the host.

The preformed resistance factors were discussed by SCHÖNBECK and four papers provided new information on the role of saponins, sterols and glucosidase enzymes. KUC's report on phytoalexins was amplified by several papers. His result on induced protection of cucumber leaves by prior inoculation with *C. lagenarium* attracted much comment. This protection is systemic in nature and is not related to phytoalexin production. A lecture on the induction of host hypersensitive response was given by SIJPESTEIJN, while on hypersensitive reaction caused by bacteria by SEQUEIRA. He stressed the protection (suppression) of the hypersensitive reaction, calling attention to the wound hormone hypothesis of RYAN. Wounding releases a hormone that induces the accumulation of proteinase inhibitors. Proteinases of pathogens would be inhibited which means that an immune response develops in the plant as a consequence of injury.

The volume is concluded with a summary by WOOD on "Specificity, an assessment".

Professors WOOD and GRANITI did an excellent work in editing this book in the present form, which gives a balanced mixture of results, ideas, criticisms, speculations, provocative comments and occasionally perhaps even idiosyncrasy. This volume is highly recommended to all plant scientists in addition to plant pathologists.

Z. KIRÁLY

NOTICE: FIFTH SYMPOSIUM ON LIVING AND FOSSIL DIATOMS. ANTWERP, BELGIUM. SEPTEMBER 4–8, 1978

This is the first announcement for the Symposium on Living and Fossil Diatoms to be held on *September 4–8, 1978* at the Societé Royale de Zoologie D'Anvers in Antwerp, Belgium. Scientists working on the ecology, biostratigraphy and taxonomy of Living and Fossil Diatoms are invited to attend the symposium and to present papers or demonstrate their work. March 1. 1978 deadline for abstracts, June 1, 1978 publication of 2nd Circular to those responding to this Circular. For preliminary registration and submission of titles of contributed papers mail to *Dr. John A. Barron, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025. U.S.A.*

INDEX

Borbély, F.—Borbély, I.—Elek, E.—Kecskés, M.: Mass of weeds and the frequency of weed species affected by herbicides in a lupin culture-consociation 269

Borhidi, A.—Muñiz, O.: Plantas nuevas en Cuba V. 295

Fekete, G.—Précsényi, I.—Molnár, E.—Melkó, E.: Niche studies on some plant species of a grassland community I. Comparison of various measurements 321

Gönczöl, J.: Clavatospora flagellata sp. nov. an aquatic Hyphomycete from Hungary 355

Hortobágyi, T.: On the thick-spined species of Micractinium 361

Horváth, M. M.—Nemcsók, J.: Changes in the peroxidase enzyme and in its ability to hydroxylate under the effect of actinomycin D and chloramphenicol in seedling bean plants 367

Komáromy, P. Zs.: Soil algal growth types as edaphic adaptation in Hungarian forest and grass steppe ecosystems 373

Lakatos, Gy.: On the photosynthesis and chlorophyll efficiency in benthonic communities dominated by Vaucheria dichotoma Agh. in lake Velence (Hungary) 381

Medve, F.: Air pollution of the ecosystem area of an oakwood and the natural 3,4 benzopyrene content of the soil and plant samples in the ecosystem 393

Melkó, E.: Numerical taxonomic studies on Iris pumila L. by cluster analysis 403

Nosek, J. N.: Comparative analysis of some diversity functions under different conditions of sampling in sandy meadow 415

Orbán, S.—Pócs, T.: Rhodobryum ontariense (Kindb.) Kindb. in Central Europe ... 437

Rowley, J. R.—Járai-Komlódi, M.: Observation of one pollen grain by SEM, TEM, and light microscopy 449

Szujkó-Lacza, J.: The current space demand and its variability during development of Pimpinella anisum L. 463

Recensiones 475

Printed in Hungary

A kiadásért felel az Akadémiai Kiadó igazgatója — Műszaki szerkesztő: Botyánszky Pál

A kézirat nyomdába érkezett: 1977. II. 23. — Terjedelem: 19 (A/5) ív, 76 ábra

77.4228 Akadémiai Nyomda, Budapest — Felelős vezető: Bernát György

ACTA BOTANICA

ТОМ 22 – ВЫП. 3–4

РЕЗЮМЕ

ВЛИЯНИЕ ГЕРБИЦИДОВ НА ЧАСТОТУ СОРНЯКОВ В КУЛЬТУРНЫХ КОНСОЦИАЦИЯХ LUPINUS

Ф. БОРБЕЙ, И. БОРБЕЙ, Е. ЭЛЕК, М. КЕЧКЕШ

Авторы исследовали влияние 108 контактных и системных препаратов гербицида, относящихся в 24 химические группы, на распространение сорняков в культурных консоциациях в конце лета а также на число особей, фитомассу сорняков, на число особей *Lupinus albus* и *Lupinus luteus* и на их биологическую продукцию (количество семян), главное место разведения люпинов в Венгрии Ниршег, на слабо кислых лесных почвах. Опыты проводились на небольших участках в 1971, 1972 и в 1973 году. На основании ранее полученных данных опрыскивание гербицидами происходило в дозе 3,5 кг/гектар. Влияние гербицидов на понижение фитомассы сорняков и повышение продукции видов люпина исследовали при помощи перечисленных параметров, а также отдельно оценивали каждый из 108 препаратов. На опытном участке частоту доминантных видов сорняков, в случае *Setaria glauca* главным образом подавляли препараты, в которых находились производные карбомида, триазина, урацила а также комбинации гербицидов. *Setaria glauca* была резистентна, вернее толерантна к 74% гербицидов. В отличии от этого *Chenopodium album* был сензитивен к 64% гербицидов. По анализу количества сорняков в конце лета больше одной трети изученных гербицидов [42] показали влияние на снижение числа особей, более 50%. Значительное число гербицидов снижало вес сорняков. Это означает, что вместе с измерением числа сорняков необходимо измерять их вес. На основании количества особей культурных растений и их продукции (вес семян) авторы определили, что из двух видов, которые принадлежат к одному и тому же семейству *Chenopodium album* был более чувствительным к гербицидам. Сравнивая некоторые химические группы с комбинациями, состоящими из двух гербицидов, оказалось, что они не оказывали более активного действия, но надо заметить, что из 108 препаратов только 16 были комбинационными.

В то же время, оценивая по отдельности препараты, оказалось, что среди комбинаций и гербицидов, содержащих один действующий агент, с точки зрения уничтожения сорняков более перспективным кажется Linuron 50 для обоих видов *Lupinus* а для *L. albus* Camparol 1803.

НОВЫЕ РАСТЕНИЯ НА КУБЕ V.

А. БОРХИДИ, О. МЮНИЗ

Данная статья является продолжением серии статей New Plants in Cuba I–IV b которых содержится описание 44 новых таксонов, а также ревизии некоторых полиморфных, вернее критических видов. Новые таксоны следующие: *Orchidaceae: Epidendrum*; *Piperaceae: Piper* (1 вид); *Polygonaceae: Coccoloba* (1 вид, 1 разновидность); *Mimosaceae: Pithecellobium* (1 подвид); *Caesalpiniaceae: Cassia* (2 вида), *Caesalpinia* (1 подвид); *Fabaceae: Brya* (1 вид); *Erythroxylaceae: Erythroxylon* (4 вида); *Rutaceae: Ravenia* (1 вид); *Euphorbiaceae: Acidocroton* (1 вид), *Moacroton* (1 разновидность), *Bonania* (2 вида); *Buxaceae: Buxus* (2 вида); *Aquifoliaceae: Ilex* (1 вид); *Celastraceae: Crossopetalum* (1 вид); *Sapindaceae: Thouinia* (2 вида); *Rhamnaceae: Rhamnidium* (1 вид), *Karwinskia* (1 вид); *Clusiaceae: Rheedia* (2 вида, 1 разновианость); *Flacourtiaceae: Samyda* (2 вида); *Thymeleaceae: Daphnosis* (1 разновидность); *Symplocaceae: Symplocos* (1 вид); *Borraginaceae: Cordia* (2 вида); *Verbenaceae: Callicarpa* (2 вида), *Vitex* (3 вида); *Solanaceae: Cestrum* (1 вид, 1 разновидность); *Gesneriaceae: Gesneria* (2 вида). Была приготовлена таксономическая ревизия следующих видов: *Coccoloba coriacea*, *Pithecellobium asplenifolium*, *Caesalpinia bahamensis*, *Rheedia fruticosa* s. l. и *Rheedia ruscifolia* а также ключ для определения кубинских видов *Rheedia*.

ПРИМЕНЕНИЕ АНАЛИЗА NICHE ДЛЯ НЕКОТОРЫХ ВИДОВ ПЕСЧАННОСТЕПНЫХ АССОЦИАЦИЙ I.

Сравнение различных индексов

Г. ФЭКЭТЭ, И. ПРЕЧЕНЬИ, Э. МОЛЬНАР, Э. МЕЛКО

В серии статей авторы дают анализ реляции — niche для доминантнообундантных видов песчанно-степных ассоциаций. В первой статье, измеряя в димензии *niche* (влажность почвы, максимальная глубина корневой массы, в дальнейшем: глубина корней), определили параметры ширины- niche: на основе формулы SHANNON вычислили равномерность (H_i), индекс COLWELL—FUTUYMA (1971) на основании формулы SHANNON ($C\ i;\ w$), два индекса PIELOU (1972) на общую (h_i/b) и весовую ширину (u_i/h_ib), индекс LEVINS (1968) B_i. Индекс overlap: HORN (1966) R_{hi}; WHITTAKER—FAIRBANKS (1958), LEVINS (1968) α_{hi}, или компетиционный коэффициент, расстояние по эуклиду (ORLOCI 1967), и в конце значение D. Методом COLWELL—FUTUYMA трансформировали расчеты других индексов калькулированными весами и основными данными.

В обоих димензиях LEVINS B_i лучше всего оценивались другие индексы (судя по оценке рангкорреляции). На различную природу индексов указывает то, что во многих случаях соответствие показывают не различные весовые индексы, как например весовой индекс не с весовой формулой. Весовой индекс PIELOU как и ожидалось был чувствителен к релативной частоте вида, а индекс COLWELL—FUTUYMA был чувствителен к релативной частоте вида, и индекс COLWELL—FUTUYMA был чувствителен к категориям. Индекс HORN R_{hi} во многих случаях давал большие значения, чем индекс C_{hi}. В случае влажности почвы общее значение у *Festuca vaginata* было самое высокое, а у *Fumana procumbens* — низкое. В случае глубины корня у *Thymus* общее значение overlap было самое высокое, а у *Fumana* самое низкое. По комбинированным категориям ширина niche, подсчитанная из community matrix, похожа на ситуацию глубины корней при community и species effect.

НОВЫЙ ВОДНЫЙ ГИФОМИЦЕТ ВЕНГРИИ CLAVATOSPORA FLAGELLATA SP. NOVA

Я. ГЕНЦЕЛЬ

Вид *Clavatospora flagellata* sp. nova был описан по погруженным в воду гниющим листьям. Описывается и иллюстрируется развитие вида на природном субстрате, его сезонная фреквенция а также распространение гриба.

О ТОЛСТОИГОЛЧАТЫХ ВИДАХ РОДА MICRACTINIUM

Т. ХОРТОБАДЬИ

В Будапештской части Дуная в 1971—1973 годах наблюдали виды *Micractinium* с необычайно толстыми иголками. В 1973 году автор уже опубликовал данные о зеленой водоросли *Micractinium crassisetum* Hortob. Новейшие наблюдения дополняют эти данные. Диаметр клеток 5,5—9; у полостных, твердых с плотными стенками иголок длина равнялась 24,7—60, а ширина у основания 1,7—2,8. Второй вид, похожий по своему строени,— *Micractinium strigoniense* Hortob. Этот вид отличается от первого единственной толстой стенкой клетки, широкой иголкой, а также наличием двух коротких тонкостенных иголок. Диаметр клетки 5—5,5; размеры длинных иголок 30—33, а более коротких 16—19. В основании ширина у первых 1,6—1,8, а у вторых 0,3—0,4. Это объединяет в себе свойства видов *M. pusillum* Fresen и *M. crassisetum* Hortob. В клетках третьего вида *Micractinium conococcoides* образовалась только одна толстостенная иголка с широким основанием. Диаметр клетки 6—7. Длина иголки 47—51, а в основании ширина равна 2,5—3. Клетки некоторых видов не располагаются в одной плоскости, они скучены, иголки направлены в разные стороны.

ИЗМЕНЕНИЯ ЭНЗИМА ПЕРОКСИДАЗЫ И ЕГО ГИДРОКСИЛЬНОЙ СПОСОБНОСТИ В ПРОРОСТКАХ ФАСОЛИ ПОД ВЛИЯНИЕМ АКТИНОМИЦИНА Д И ХЛОРАМФЕНИКОЛА

М. ХОРВАТ, И. НЕМЧОК

За последнее время изучение механизма действия пероксидазы а также ее роли в гидроксильных процессах выступило на первое место. Стало актуальным исследовать в процессе синтеза белков на различных этапах химические соединения, пригодные для полного подавления а также и для формирования пероксидазы и ее гидроксильной способности.

Из опытов можно определить, что использованные авторами подавляющие вещества (актиномицин Д и хлорамфеникол) можно использовать для торможения активности пероксидазы и ее гидроксильной способности.

ФОРМЫ РОСТА ПОЧВЕННЫХ ВОДОРОСЛЕЙ В ВЕНГЕРСКИХ ЛЕСНЫХ И СТЕПНЫХ ЭКОСИСТЕМАХ, ПРИНИМАЯ ВО ВНИМАНИЕ ФИЗИЧЕСКИЕ СВОЙСТВА ТИПОВ ПОЧВЫ

Ж. П. КОМАРОМИ

На основании изучения большого количества образцов почв автор определила, что венгерские лесные почвы похожи на другие среднеевропейские леса типа *Chlorophyta*, а степные — на почвы типа *Cyanophyta*. В настоящей статье автор пытается привести в порядок формы роста почвенных водорослей на основании концепции RAUNKIAER, принимая во внимание физические свойства типа почд. Автор определила 6 форм роста, которые можно зачислить в следующие группы: *dispersal* (1), *stratosus* (2), *Microcoleus* (3,1), *ramosus* (3,2), *Nostoc* или «*sticking*» (4), а также *glutinosus* или *Diatoma* (5). Для рыхлых лесных почв характерна *dispersal*, а для плотных почв форма *stratosus*, для степных экосистем подзольные, солончаковые корковые формы (3.1 и 3.2). Форма роста *glutinosus* чаще всего наблюдается в постоянно влажных местах. Синузимы почвенных водорослей в лесных и степных экосистемах можно хорошо характеризовать формами роста.

ИССЛЕДОВАНИЕ ФОТОСИНТЕЗА VAUCHERIA DICHOTOMA AGH И БЕНТОНИЧЕСКОЙ ЭФФЕКТИВНОСТИ ХЛОРОФИЛЛА В ОЗЕРЕ ВЕЛЕНЦЕИ

Д. ЛАКАТОШ

При обьяснении состояния эвтрофизации вод наряду с опознаванием концентрации хлорофилла ориентировочные параметры облегчают и помогают уточнить роль планктонных и бентических растений в водной экосистеме.

Для открытия свойств бентического хлорофилла были проведены фотосинтетические исследования с основной бентонической растительностью озера Веленцеи.

В процессе работы среди методов измерения фотосинтеза авторы применяли метод *dark and light bottle* с измерением O_2.

На основании опытов, проведенных летом 1973 года, были определены параметры продуктивности дёрна, *Vaucheria dichotoma*.

$$P_{O_2} = 1{,}76 \text{ mg } O_2 \text{ Dm } g^{-1} h^{-1}$$

$$P_c = 0.56 \text{ mg C Dm } g^{-1} h^{-1}$$

Ежедневная оценка продукции = 3,29 g C $m^{-2} d^{-1}$

Для ассимиляции бентического хлорофилла авторы получили оценку 0,24, фактор активности был равен 0,01.

Можно определить, что для бентонической эвтрофизации характерно определенное количество биомассы растительности, находящейся в постоянных условиях, и в связи с этим большое количество хлорофилла, а также низкая продуктивность, низкое число ассимиляции и фактор низкой фотосинтетической активности.

ЗАГРЯЗНЕНИЕ ВОЗДУХА В ДУБОВОЙ ЭКОСИСТЕМЕ И СОДЕРЖАНИЕ 3,4-БЕНЗПИРЕНА В НАХОДЯЩИХСЯ НА ЭТОЙ ПЛОЩАДИ РАСТИТЕЛЬНЫХ И ПОЧВЕННЫХ ОБРАЗЦАХ

Ф. МЕДВЕ

В статье находятся данные исследования загрязнения воздуха в одной из экосистем, на протяжении 3-х лет. Автор измерял количество осажденной пыли, летящей пыли, серы, сернистого газа, окиси азота а также исследовал содержание природного 3,4-бензпирена в растительных и почвенных образцах. Результаты можно считать данными природного фона.

НУМЕРИКО-ТАКСОНОМИЧЕСКИЕ ИЗУЧЕНИЯ IRIS PUMILA L. ПРИ ПОМОЩИ АНАЛИЗА CLUSTER

Э. МЕЛКО

Автор в первую очередь сообщает об аггломеративном анализе *cluster* по Орлоци, затем применяет его для географической или таксономической группировки *Iris pumila* L. и в конце оценивает результаты.

Исследуемый материал состоит из гербарных растений, собранных из 35 мест (+ 1 украинское) Карпатского бассейна. Основу опытов составляет измерение 14 абсолютных размеров, проведенных на листьях и трубке венчика, вернее 12 отношений, которые образовались из абсолютных размеров.

Применяя аггломеративный анализ *cluster* по Орлоци, автор провела 4 анализа. Результаты показывают, что хотя в случае каждого анализа автор получила хорошо ограниченные *cluster*, некоторые *cluster* не гомогенны ни по географическим условиям, (место нахождения, основная среда, уровень моря), ни по традиционным внутривидовым таксономическим группировкам. На основе размеров вегетативных частей, вернее на основе полученных соотношений, *Iris pumila* L. на изученных местах (Карпатский бассейн), как в географическом, так и в таксономическом аспекте нельзя подразделить на гомогенные группы. Опыты показывают, что анализ *cluster* можно применять в систематике. С помощью этого анализа на основе характерных признаков возможно группировать виды, вернее можно указать на то, что *cluster*, которые считали до сих пор едиными, в действительности едины ли.

СРАВНИТЕЛЬНЫЕ ИЗУЧЕНИЯ НЕСКОЛЬКИХ ФУНКЦИЙ РАЗНООБРАЗИЯ НА ПЕСЧАНЫХ ДЁРНАХ ПРИ ВЗЯТИИ РАЗЛИЧНЫХ ОБРАЗЦОВ

Я. НОСЕК

Автор в виде вступления сообщает о пробелах в проводившихся до сих пор опытах, и на основе разнообразия теории множества дает определение понятия (Юхас—Надь, 1973) измерения. Автор делает обзор описанных в литературе индексов и функций разнообразия и эквитабильности.

Опыты проводились на песчано-степном дёрне (*Festucetum vaginatae danubiale*) Венгрии на границе Вацратота. Были исследованы 6 функций разнообразия (Simpson, Gini, PIE McIntosh, корригированная основной множественностью числа видов функция Shannon-Weaver) а также функция эквитабильности ($D - D_{1.min.}$) $D_{1max.} - D_{1.min.}$)

В опытах имелись два условия взятия образцов:

а) Умножение площади взятия образцов по двум степеням с 100 см² до 3 200 см².

б) Изменение формы образца. Растяжение квадрата в форму кирпича. Ни функции Simpson—McIntosh и PIE, ни увеличение площади и изменение формы не показали систематической связи. С увеличением места функции Gini и Shannon логарифмически изменились. При каждой величине площади недооценивалась величина основной множественности и разнообразия.

С изменением формы до 1600 см² оба показали все более сниженную связь. Функция Shannon-Weaver, корригированная множественностью числа видов, по гиперболическому соотношению изменилась с изменением площади. До 400 см² переоценивалось разнообразие основного множества, а с 1600 см² оно недооценивалось. Изменение формы до 800 см² показало пониженную связь.

Величины эквитабильности изменялись с увеличением площади у различных форм не по одинаковым типам. Изменение формы не показало систематическую связь. В большинстве случаев была переоценена величина множественной эквитабильности.

Наилучшую оценку разнообразия множественности автор определил на площади 1600 см², имеющей форму узкого кирпича (отношение сторон 1 : 32) при помощи корригированной функции SHANNON-WEAVER.

RHODOBRYUM ONTARIENSE (KINDB.) KINDB. В СРЕДНЕЙ ЕВРОПЕ

Ш. ОРБАН, Т. ПОЧ

Авторы указали на распространение вида *Rhodobryum ontariense* (Kindb.) Kindb. в восьми странах средней Европы. Каждый из них находится в зоне лиственного леса, а также в степной лесовой зоне. Вид *R. roseum* на этой территории распространен все более и более редко, а *R. ontariense* более часто встречается на известковых почвах, в особенности в Карпатском бассейне.

ЭЛЕКТРОННОМИКРОСКОПИЧЕСКОЕ ИССЛЕДОВАНИЕ ОДНИХ И ТЕХ ЖЕ ПЫЛЬЦЕВЫХ ЗЕРЕН ПРИ ПОМОЩИ СЭМ, ТЭМ и СМ

И. РОУЛЕЙ, М. ЯРАИ-КОМЛОДИ

Авторы исследовали субмикроскопическое строение видов *Linum* при помощи светового микроскопа (СМ), электронного микроскопа сканнинг (СЭМ) и трансмиссионного электронного микроскопа (ТЭМ).

Для сравнения полученных данных необходимо обрабатывать материал одним и тем же способом, т. е. те же самые пыльцевые зерна возможно исследовать выше названными микроскопами. В палинологии до сих пор это методически было невозможно. Для того чтобы собрать вместе различные подготовительные методы, нужно было выработать новый метод.

В этой статье авторы дают отчет об этом методе и о полученных результатах.

АКТУАЛЬНАЯ ПОТРЕБНОСТЬ В ПЛОЩАДИ И ЕЁ ВАРИАБИЛЬНОСТЬ В ПРОЦЕССЕ РАЗВИТИЯ ВИДА PIMPINELLA ANISUM L.

Ю. СУЙКО-ЛАЦА

Автор в этой статье продолжает квантитативный морфологический анализ аниса, отыскивает и измеряет такие точки, на основании которых можно высчитать площадь, занятую одной особью в данной стадии развития и внутри фенофазы. Поскольку эта площадь связана со стадией онтогенеза, она получила название актуальной потребности в площади (АПП). В исследованной популяции была замечена вариабильность в уровне развития и потребности в территории. Максимум АПП можно было измерять в более развитом (p_1) и слабо развитом (p_2) образце в одной и той же стадии развития и фенофазе, однако в абсолютной оценке, а также в архитектуре была значительная разница между p_1 и p_2.

Эквифинитивность Недлера (Ошват 1964) между p_1 и p_2 не наступила даже во время полного созревания семян.

Ухудшение окружающих условий (высокая темература и большая интенсивность света) оказало более вредное влияние на p_2, чем на p_1.

По расчетам оказалось, что одной из причин развития и вариабильности АПП является сигнификантное различие в весе между семенами, которые развились из побочного соцветия и из главного стебля. Во время прорастания, в стадии гетеротрофного питания, особи с небольшим весом семян, происходящие с побочных зонтиков, развиваются с таким ущербом, который проявляется в внутривидовой компетиции в развитии а также на уровне АПП, и это возможно измерять (Куроива 1960).

The *Acta Botanica* publish papers on botanical subjects in English, French, German and Russian.

The *Acta Botanica* appear in parts of varying size, making up volumes.

Manuscripts should be addressed to:

Acta Botanica, Budapest 502, Postafiók 24.

Correspondence with the editors and publishers should be sent to the same address.

The rate of subscription is $ 32.00 a volume.

Orders may be placed with "*Kultúra*" Foreign Trade Company (1389 Budapest 62, P.O.B. 149. Account No. 218-10990) or with representatives abroad.

Les *Acta Botanica* paraissent en français, allemand, anglais et russe et publient des travaux du domaine des sciences botaniques.

Les *Acta Botanica* sont publiés sous forme de fascicules qui seront réunis en volumes.

On est prié d'envoyer les manuscrits destinés à la rédaction à l'adresse suivante:

Acta Botanica, Budapest 502, Postafiók 24.

Toute correspondance doit être envoyée à cette même adresse.

Le prix de l'abonnement est de $ 32.00 par volume.

On peut s'abonner à l'Entreprise du Commerce Extérieur «*Kultúra*» (1389 Budapest 62, P.O.B. 149 Compte-courant No. 218-10990) ou à l'étranger chez tous les représentants ou dépositaires.

«*Acta Botanica*» публикуют трактаты из области ботаники на русском, английском, французском и немецком языках.

«*Acta Botanica*» выходят отдельными выпусками разного объема. Несколько выпусков составляют один том.

Предназначенные для публикации рукописи следует направлять по адресу:

Acta Botanica, Budapest 502, Postafiók 24.

По этому же адресу направлять всякую корреспонденцию для редакции и администрации. Подписная цена — $ 32.00 за том.

Заказы принимает предприятие по внешней торговле «*Kultúra*» (1389 Budapest 62, P.O.B. 149. Текущий счет № 218-10990), или его заграничные представительства и уполномоченные.

Reviews of the Hungarian Academy of Sciences are obtainable at the following addresses:

AUSTRALIA
C.B.D. LIBRARY AND SUBSCRIPTION SERVICE Box 4886, G.P.O., *Sydney N.S.W. 2001*
COSMOS BOOKSHOP, 145 Ackland Street, *St. Kilda (Melbourne), Victoria 3182*

AUSTRIA
GLOBUS, Höchstädtplatz 3, *1200 Wien XX*

BELGIUM
OFFICE INTERNATIONAL DE LIBRAIRIE, 30 Avenue Marnix, *1050 Bruxelles*
LIBRAIRIE DU MONDE ENTIER, 162 Rue du Midi, *1000 Bruxelles*

BULGARIA
HEMUS, Bulvar Ruszki 6, *Sofia*

CANADA
PANNONIA BOOKS, P.O. Box 1017, Postal Station "B", *Toronto, Ontario M5T 2T8*

CHINA
CNPICOR, Periodical Department, P.O. Box 50, *Peking*

CZECHOSLOVAKIA
MAD'ARSKÁ KULTURA, Národní třida 22, *115 66 Praha*
PNS DOVOZ TISKU, Vinohradská 46, *Praha 2*
PNS DOVOZ TLAČE, *Bratislava 2*

DENMARK
EJNAR MUNKSGAARD, Norregade 6, *1165 Copenhagen*

FINLAND
AKATEEMINEN KIRJAKAUPPA, P.O. Box 128, *SF-00101 Helsinki 10*

FRANCE
EUROPERIODIQUES S. A., 31 Avenue de Versailles, *78170 La Celle St.-Cloud*
LIBRAIRIE LAVOISIER, 11 rue Lavoisier, *75008 Paris*
OFFICE INTERNATIONAL DE DOCUMENTATION ET LIBRAIRIE, 48 rue Gay-Lussac, *75240 Paris Cedex 05*

GERMAN DEMOCRATIC REPUBLIC
HAUS DER UNGARISCHEN KULTUR, Karl-Liebknecht-Strasse 9, *DDR-102 Berlin*
DEUTSCHE POST ZEITUNGSVERTRIEBSAMT, Strasse der Pariser Kommüne 3—4, *DDR-104 Berlin*

GERMAN FEDERAL REPUBLIC
KUNST UND WISSEN ERICH BIEBER, Postfach 46, *7000 Stuttgart 1*

GREAT BRITAIN
BLACKWELL'S PERIODICALS DIVISION, Hythe Bridge Street, *Oxford OX1 2EU*
BUMPUS, HALDANE AND MAXWELL LTD., Cowper Works, *Olney, Bucks MK46 4BN*
COLLET'S HOLDINGS LTD., Denington Estate, *Wellingborough, Northants MN8 2QT*
WM. DAWSON AND SONS LTD., Cannon House, *Folkestone, Kent CT1 5EE*
H. K. LEWIS AND CO., 136 Gower Street, *London WC1E 6BS*

GREECE
KOSTARAKIS BROTHERS, International Booksellers, 2 Hippokratous Street, *Athens-143*

HOLLAND
MEULENHOFF-BRUNA B.V., Beulingstraat 2, *Amsterdam*
MARTINUS NIJHOFF B.V., Lange Voorhout 9—11, *Den Haag*
SWETS SUBSCRIPTION SERVICE, 347b Heereweg, *Lisse*

INDIA
ALLIED PUBLISHING PRIVATE LTD., 13/14 Asaf Ali Road, *New Delhi 110001*
150 B-6 Mount Road, *Madras 600002*
INTERNATIONAL BOOK HOUSE PVT. LTD., Madame Cama Road, *Bombay 400039*
THE STATE TRADING CORPORATION OF INDIA LTD., Books Import Division, Chandralok, 36 Janpath, *New Delhi 110001*

ITALY
EUGENIO CARLUCCI, P.O. Box 252, *70100 Bari*
INTERSCIENTIA, Via Mazzé 28, *10149 Torino*
LIBRERIA COMMISSIONARIA SANSONI, Via Lamarmora 45, *50121 Firenze*
SANTO VANASIA, Via M. Macchi 58, *20124 Milano*
D. E. A., Via Lima 28, *00198 Roma*

JAPAN
KINOKUNIYA BOOK-STORE CO. LTD., 17-7 Shinjuku-ku 3 chome, Shinjuku-ku, *Tokyo 160-91*
MARUZEN COMPANY LTD., Book Department, P.O. Box 5050 Tokyo International, *Tokyo 100-31*
NAUKA LTD. IMPORT DEPARTMENT, 2-30-19 Minami Ikebukuro, Toshima-ku, *Tokyo 171*

KOREA
CHULPANMUL, *Phenjan*

NORWAY
TANUM-CAMMERMEYER, Karl Johansgatan 41—43, *1000 Oslo*

POLAND
WĘGIERSKI INSTYTUT KULTURY, Marszałkowska 80, *Warszawa*
CKP I W ul. Towarowa 28 *00-958 Warsaw*

ROUMANIA
D. E. P., *Bucureşti*
ROMLIBRI, Str. Biserica Amzei 7, *Bucureşti*

SOVIET UNION
SOYUZPETCHATY — IMPORT, *Moscow*
and the post offices in each town
MEZHDUNARODNAYA KNIGA, *Moscow G-200*

SPAIN
DIAZ DE SANTOS, Lagasca 95, *Madrid 6*

SWEDEN
ALMQVIST AND WIKSELL, Gamla Brogatan 26, *S-101 20 Stockholm*
GUMPERTS UNIVERSITETSBOKHANDEL AB, Box 346, *401 25 Göteborg 1*

SWITZERLAND
KARGER LIBRI AG, Petersgraben 31, *4011 Basel*

USA
EBSCO SUBSCRIPTION SERVICES, P.O. Box 1943, *Birmingham, Alabama 35201*
F. W. FAXON COMPANY, INC., 15 Southwest Park, *Westwood, Mass. 02090*
THE MOORE-COTTRELL SUBSCRIPTION AGENCIES, *North Cohocton, N. Y. 14868*
READ-MORE PUBLICATIONS, INC., 140 Cedar Street, *New York, N. Y. 10006*
STECHERT-MACMILLAN, INC., 7250 Westfield Avenue, *Pennsauken N. J. 08110*

VIETNAM
XUNHASABA, 32, Hai Ba Trung, *Hanoi*

YUGOSLAVIA
JUGOSLAVENSKA KNJIGA, Terazije 27, *Beograd*
FORUM, Vojvode Mišiča 1, *21000 Novi Sad*

31. XII. 1977 Index: 26.001